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THE MODERN ELECTROPLATER

A complete book considering fully the elementary principles of Electro Deposition of Metals, their practical application and industrial use.

Includes

A discussion of the essential fundamentals of Chemistry, Magnetism and Electricity, written with special reference to the needs of the practical man; considers the equipment and supplies required for a successful plating plant and describes all the latest processes of cleaning, plating and finishing metals on a commercial scale.

BY

KENNETH M. COGGESHALL

Electrical Engineer

Including Valuable Tables and Tested Formulas

NEW YORK

THE NORMAN W. HENLEY PUBLISHING CO.

2 WEST 45TH STREET

1920

TS670
.C6

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THE NORMAN W. HENLEY PUBLISHING COMPANY

Printed in U. S. A.

20-17581

SEP 22 1920

PUBLISHERS PRINTING COMPANY, NEW YORK

©CI.A597488

PREFACE

The aim of this book is not scientific, but practical. An attempt has been made to describe the equipment and to explain the practical methods of modern electroplating in the simplest possible terms. No material has been put into the book which does not bear directly upon the subject of electro-deposition. For example, only the essential fundamentals of magnetism, electricity, and chemistry have been considered.

Chapter VIII, which deals with electrolytic solutions and plating methods, is presented with the cooperation of Mr. Harry Duebelbeis, president of the American Electroplaters' Society, St. Louis Branch.

The author takes this opportunity of expressing his indebtedness to his father and to Mr. Mark Moody for many valuable suggestions and friendly criticisms.

The writer is also under obligations to several manufacturers and suppliers for cuts and illustrations of plating and polishing room equipment. Acknowledgment is given with the title for the illustrations furnished by the Mott Sand Blast Co., the L. S. Starrett Co., Crown Rheostat & Supply Co., General Platers' Supply Co., A. P. Munning & Co., The Baird Machine Co., Sangamo Electric Co., and Bennett O'Connell Co.

August, 1920. KENNETH M. COGGESHALL.

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The Modern Electroplater

CHAPTER I

THE ADVANCE OF THE ELECTROPLATING INDUSTRY

Electroplating: a Definition—Development of the Industry—Metal Deposition for Protection—Electrotyping—Deposition of Precious Metals—Research Work—An Essential Industry—Future Development.

ELECTROPLATING

Electroplating consists in the deposition of a layer of metal upon an object through the action of electrolysis.

DEVELOPMENT OF THE INDUSTRY

Although the discovery of electro-deposition was made in 1805, it was not until 1837 that Spencer and Jacobi made use of the phenomenon for practical purposes. Scientific investigation, continued in the laboratories, developed and broadened the scope of the subject. Gradually the possibilities of the art of electroplating became apparent to manufacturers who adapted the process to electrotyping, as well as to the coating of small articles. Only recently has the chemist considered electroplating as an important industry well worthy of his serious study. Careful

laboratory investigations, concentrated study of chemical and electrical phenomena, combined with practical experience, have evolved processes and formulæ designed to produce definite results and perfect deposition at a minimum cost. Moreover, manufacturers of electroplating machinery, stimulated perhaps by competition, have year by year improved their apparatus in an effort to gain the highest degree of efficiency. The modern electroplater is quick to grasp and employ to his advantage every new process as well as every improvement in labor saving machinery.

METAL DEPOSITION FOR PROTECTION

It is well known that iron and steel products corrode or rust quickly if exposed directly to the atmosphere. Yet because the metals are available in large quantities, are comparatively inexpensive, and since they are strong and durable, commercial practice demands their use. Thus, some protective coating must be used, whether it be paint, varnish, or a layer of non-corrosive metal. In some instances paint or varnish may be used, but greater satisfaction results if a thin deposit of zinc, nickel, tin, or copper is applied. These metals not only afford the necessary protection but greatly improve the appearance of the treated product. Zinc, unlike tin or nickel, is electro-positive to iron and is, therefore, an excellent protective agent. Moreover, its cost is less than the other metals mentioned. Nickel, however, because of the high polish it takes on the buffing wheel, is usually employed as a coating for hardware and other parts requiring a beautiful, finished sur-

face. Tin is not used to as great an extent as the others, but copper is often employed. Undoubtedly the deposition of protective metals is at present the most important phase of the electroplating industry. Indeed, electro-galvanizing or zinc plating is of such importance that entire plants are equipped solely for that work.

ELECTROTYPING

Type and other objects may be reproduced by the electro deposition of copper upon a mould of the original. Thus, any number of exact metallic reproductions may be made from the original type or cut. Perhaps no other art has assisted to so great a degree the progress of the printing industry as has electroplating.

DEPOSITION OF PRECIOUS METALS

Although the greatest volume of work passing through most plating rooms at the present time calls for the deposition of protective metals, gold and silver plating, particularly the latter, have a wide application. Usually the deposition of these metals is done for ornamental purposes. Jewelry, cutlery, table ware, and similar articles made from baser metals, are coated with gold and silver to improve their appearance as well as to increase their value.

RESEARCH WORK

The applications of the art of electroplating just mentioned are only the most important. The field is continually growing broader. In a great measure the future development of this industry depends upon the

interchanging of experiences and opinions of electroplaters through the channels of the various trade papers and societies. The United States Bureau of Standards is carrying on research work with the expectation of solving many of the existing plating problems as well as presenting new processes, solutions, and other interesting data.

AN ESSENTIAL INDUSTRY

The World War, to a certain degree, assisted in placing electroplating among the essential industries. Manufacturers accustomed to the use of brass or copper suddenly found those metals listed as necessary for the production of munitions. Thus other metals were employed and electroplated to secure the desired finish. Quantities of rejected underweight steel explosive shells were salvaged by the electro-deposition of lead upon their interior walls. Countless steel parts were zinc plated as a protection against exposure to the atmosphere. The writer, for instance, was interested in the production of thousands of "depth bombs," practically every part of which passed through the plating room. Under the pressure of war work many plating establishments, of necessity, applied the rules of efficiency, purchased new machinery, and, using the same floor space, increased production to a previously unthought-of extent. These lessons cannot soon be forgotten.

FUTURE DEVELOPMENT

Automatic machinery is appearing to lessen the labor of plating, as well as to reduce its cost. The modern plating room is equipped with plating bar-

rels, automatic conveyors for still tanks, steel ball burnishers, and similar apparatus. The plating room of the future will be equipped entirely with such labor-saving machinery; operations will be standardized; work will move in a definite path through the room; the quality of the deposit will be uniform, and quantity production will be demanded.

CHAPTER II

ELEMENTARY CHEMISTRY AND ELECTRICITY

Chemical Affinity—Elements—Compounds—Chemical Symbols—Tabulation of Elements—Atomic Theory—Atoms—Molecules—Law of Multiple Proportions—Acids—Bases—Salts—Chemical Equations—Common and Technical Names—Solids and Solutions—Electro-Chemical Action—Electrolysis—Electro-Deposition of Metals—Faraday's Laws—Electrical Conductors—The Electric Circuit—The Ampere—The Volt—Potential Difference—The Ohm—Resistance Factors—Series Circuits—Parallel Circuits—The Coulomb—The Joule—The Watt—The Watt-Hour—The Horse Power.

It is not necessary that an electroplater be a careful student of either electricity or chemistry. A technical discussion of the laws relating to electro-chemistry would, undoubtedly, have but little interest for even an expert plater. His attention is usually directed first and chiefly to the *how* rather than the *why* of electro-deposition. Progress is stimulated, however, by taking advantage of the experience of co-workers in the art of plating, and proceeding with the work from the point to which others have advanced it. Much of such useful information is found in current magazines of the trade expressed in the form of chemical equations or written in terms of

electrical units. Thus, a brief review of the fundamental facts and principles of these subjects should prove helpful to the electroplater.

CHEMICAL AFFINITY

It was discovered, some few years ago, that most substances can, by chemical action, be converted into more simple substances. At present about eighty substances are known which cannot be further decomposed; these the scientists term elements. As yet it is not fully understood what power holds the elements together in the many combinations. This phenomenon, causing various substances to form in combinations of two to six or more elements, is termed chemical affinity. Fortunately, but few elements are of concern to the electroplater.

ELEMENTS

Elements are those substances incapable of separation into other kinds of matter. Metals, such as iron, lead, zinc, gold and silver, are elements, as are also gases, like hydrogen, nitrogen, oxygen and chlorine. Not all elements are conductors of electricity; some are not even good conductors of heat.

COMPOUNDS

Compounds, as the name implies, are composed of several substances. It is therefore true that a compound may be broken up into the elements of which it is composed. Water, H_2O, the most bountiful of all compounds, is composed of two familiar elements, hydrogen and oxygen. As a further example, silver

nitrate, $AgNO_3$, can be separated into the elements silver, nitrogen, and oxygen, of which it is compounded.

CHEMICAL SYMBOLS

It would not be an easy matter to express a chemical substance or reaction by writing out in full the name of each element involved. To save time, therefore, as well as to express a letter picture of the combination of elements, a kind of shorthand has been evolved to represent the names of substances.

In a number of instances the first letter of the Latin name is the symbol. Thus, the Latin name for potassium is Kalium, and K is the symbol for that element. Other symbols take the first letter and some other letter in the word. For instance, tin is Stannum in Latin, and Sn is the chemical symbol. As will be noticed, however, from the following list of elements, most of the symbols have their origin in the English name; as H for hydrogen and Cl for chlorine.

TABULATION OF ELEMENTS

ELEMENT	SYMBOL	ATOMIC WEIGHT
Aluminum	Al	27.1
Antimony	Sb	120.2
Argon	A	39.9
Arsenic	As	75.
Barium	Ba	137.4
Bismuth	Bi	208.
Boron	B	11.
Bromine	Br	79.96
Cadmium	Cd	112.4
Cæsium	Cs	132.9
Calcium	Ca	40.1
Carbon	C	12.
Cerium	Ce	140.25

ELEMENT	SYMBOL	ATOMIC WEIGHT
Chlorine	Cl	35.45
Chromium	Cr	52.1
Cobalt	Co	59.
Columbium	Cb	94.
Copper	Cu	63.6
Erbium	E	166.
Europium	Eu	152.
Fluorine	F	19.
Gadolinium	Gd	156.
Gallium	Ga	70.
Germanium	Ge	72.5
Glucinum	Gl	9.1
Gold	Au	197.2
Helium	He	4.
Hydrogen	H	1.008
Indium	In	115.
Iodine	I	126.97
Iridium	Ir	193.
Iron	Fe	55.9
Krypton	Kr	81.8
Lanthanum	La	138.9
Lead	Pb	206.9
Lithium	Li	7.03
Magnesium	Mg	24.36
Manganese	Mn	55.
Mercury	Hg	200.
Molybdenum	Mo	96.
Neodymium	Nd	143.6
Neon	Ne	20.
Nickel	Ni	58.7
Nitrogen	N	14.01
Osmium	Os	191.
Oxygen	O	16.
Palladium	Pd	106.5
Phosphorous	P	31.
Platinum	Pt	194.8
Potassium	K	39.15
Praseodynium	Pr.	140.5
Radium	Ra	225.
Rhodium	Rh	103.
Rubidium	Rb	85.5
Ruthenium	Ru	101.7
Samarium	Sm	150.3
Scandium	Sc	44.1
Selenium	Se	79.2
Silicon	Si	28.4
Silver	Ag	107.93

ELEMENT	SYMBOL	ATOMIC WEIGHT
Sodium	Na	23.05
Strontium	Sr	87.6
Sulphur	S	32.06
Tantalum	Ta	181.
Tellurium	Te	127.6
Terbium	Tb	159.2
Thallium	Tl	204.1
Thorium	Th	232.5
Thulium	Tu	171.
Tin	Sn	119.
Titanium	Ti	48.1
Tungsten	W	184.
Uranium	U	238.5
Vanadium	V	51.2
Xenon	X	128.
Ytterbium	Yb	173.
Yttrium	Y	89.
Zinc	Zn	65.4
Zirconium	Zr	90.6

ATOMIC THEORY

In order that the combinations of elements as expressed in chemical formulæ may be comprehended, the reader must understand something of the atomic theory. It is known that elements combine in definite proportions. Moreover, when elements combine with others in different ways, the relative quantities that make up the combination, in the several instances, follow out definite laws.

ATOMS

Every simple substance or element is supposed to be made up of atoms, all of which are alike and of the same weight. Chemical combination of different substances takes place between these particles or atoms. The atoms of one element have a different weight from those of other elements. It is not nec-

essary to know the absolute weight of the atoms, but the relative weight is most important. The atomic weight of hydrogen is taken as the unit for the system, and for all practical purposes may be considered as unity. By reference to the tabulation it is seen that the atomic weight of chlorine is 35.45. Thus, the familiar hydrochloric acid, HCl, is a compound composed of 35.45 parts by weight of chlorine to 1 part of hydrogen. Common table salt, NaCl, is a combination of 23.05 parts by weight of sodium to 35.45 parts of chlorine. In practice the symbols shown in the table are used to express the relative weights. Hence, Al stands for 27.1 parts by weight of aluminum, C for 12 parts by weight of carbon, Sn for the atomic weight of tin, and so on.

MOLECULES

We have now seen that the atom is the smallest particle of an element considered in chemical action. Atoms of several elements, however, may combine to form particles of a larger degree, called molecules. Thus, HCl denotes a molecule of hydrochloric acid, which is composed of an atom of hydrogen and one of chlorine.

When two or more atoms of one element combine with those of other elements, the total number of each above one entering into the combination is indicated by a numeral placed at the lower right hand corner of the letter symbol. Take, for example, the formula for water, H_2O. The numeral 2 appearing after the H denotes that two hydrogen atoms have combined with one of oxygen. Sulphuric acid, H_2SO_4, is so written that the combination is apparent: two hydro-

gen atoms, one sulphur, and four oxygen atoms. Often the molecular composition is more complex, as is indicated in the formula for ferric sulphate, $Fe_2(SO_4)_3$. As is at once seen, the molecule is composed of: iron, two atoms; sulphur, three atoms, and oxygen, twelve atoms, or a total of seventeen atoms. Some molecules are combinations of a large number of atoms. Note, for example, the formula for the familiar substance sugar: $C_{12}H_{22}O_{11}$.

The number of molecules is expressed by a large numeral preceding the symbol. Hence, if 6 molecules of sulphuric acid are to be used, it is apparent that they would be grouped together and written $6H_2SO_4$.

LAW OF MULTIPLE PROPORTIONS

From the preceding brief discussion of atoms and molecules it is seen that the atoms always combine in definite proportions. But a glance at the formulæ given as examples undoubtedly shows that there must be some law causing the elements to combine in more than one proportion. The law of multiple proportions, first conceived by Dalton, states that the combining weights of elements are always multiples of each other. This law may be more clearly illustrated by the usual example of two elements, A and B. If A combines with a certain weight of B in more than one proportion, then the different combining weights of A with B always show some definite ratio or multiples of each other, such as 1 : 2, 2 : 3. There are many elements that combine in several different ways, but the following tabulation of the multiple proportions of two abundant substances, lead and oxygen, gives a fair example.

Name	Formula	Parts by Weight		Ratio of	
		Pb	O	Pb	to O
Lead Suboxide	Pb_2O	414	16	207	8
Lead Oxide	PbO	207	16	207	16
Lead Sesquioxide ...	Pb_2O_3	414	48	207	24
Lead Peroxide	PbO_2	207	32	207	32

ACIDS

Before going further, a distinction should be made between acids, bases, and salts that are formed by combination of several elements. By studying the symbols of various acids and their reactions with other substances, it will be noticed that an acid always contains hydrogen which it will exchange for a metal, when a metal or its compound is added. Hydrochloric acid, HCl, is an example.

BASES

On the other hand, substances containing a metal in combination with oxygen and hydrogen, which will exchange the metal for hydrogen when an acid is added, are termed bases. Sodium hydroxide, NaOH, is a base.

SALTS

When an acid acts upon a base, water and another substance called a salt are formed. Zinc sulphate, $ZnSO_4$, is known as a salt.

CHEMICAL EQUATIONS

To express chemical action, equations are used, similar to those employed in algebra. The action of any substance upon another is indicated by coupling them with a plus sign. The factors in the transformation

precede an equality sign and the result of the reaction follows. The sum of the atomic weight, in other words, on one side of the equation must equal the sum of those written on the opposite side. Nothing is lost during a chemical transformation; new substances may be formed, but the same weight of matter is present after the action as before.

It may be interesting to note a few simple changes as represented by an equation. Zinc, when acted upon by sulphuric acid, produces a salt, zinc sulphate, and a gas hydrogen. The story of the chemical transformation may be written in the form of an equation.

$$Zn+H_2SO_4=ZnSO_4+2H$$

The base, ammonium hydroxide, when treated with hydrochloric acid, reacts to give water and ammonium chloride, or what is commercially known as sal ammoniac:

$$NH_4(OH)+HCl=H_2O+NH_4Cl$$

A few other simple chemical reactions, expressed in the form of equations, are given to illustrate further similar transformations:

$$Zn+2HCl=ZnCl_2+2H$$
$$ZnCl_2+2KCN=2KCl+Zn(CN)_2$$
$$Cu+H_2SO_4=CuO+SO_2+H_2O$$
$$CuO+H_2SO_4=CuSO_4+H_2O$$
$$NiCl_2+6NH_3=Ni(NH_3)_6Cl_2$$
$$Ag_2O+2HNO_3=2AgNO_3+H_2O$$
$$NH_3+HCl=NH_4Cl$$
$$NaNO_3+H_2SO_4=NaHSO_4+HNO_3$$
$$PbO_2+4HCl=PbCl_2+2H_2O+2Cl$$

COMMON AND TECHNICAL NAMES

One confusing factor in the study of chemistry is the designation of a given substance by two or more names. For illustration, the familiar blue vitriol or blue stone is technically termed copper sulphate. In like manner, muriatic and hydrochloric acid are identical, although one unfamiliar with the terms might assume them to be two distinct substances. For convenience, a reference tabulation is given, containing the common and technical names of substances often used in the plating room:

Common Name	Technical Name
Baking Soda	Sodium Bicarbonate
Blue Stone	Copper Sulphate
Blue Vitriol	Copper Sulphate
Common Salt	Sodium Chloride
Copperas	Ferrous Sulphate
Corrosive Sublimate	Mercuric Chloride
Glaubers Salts	Sodium Sulphate
Iron Chloride	Ferric Chloride
Iron Oxide	Ferric Oxide
Muriatic Acid	Hydrochloric Acid
Oil of Vitriol	Sulphuric Acid
Prussic Acid	Hydrocyanic Acid
Sal Ammoniac	Ammonium Chloride
Sal Soda	Sodium Carbonate
Saltpetre	Potassium Nitrate
Sugar of Lead	Lead Acetate
Tartar Salts	Potassium Carbonate
Tin Chloride	Stannous Chloride
White Lead	Lead Carbonate
White Vitriol	Zinc Sulphate

SOLIDS AND SOLUTIONS

Chemical action does not readily take place between solid substances, and it is, therefore, often necessary to dissolve them in water. No matter how finely the substances may be divided by pulverizing, the particles are not in as intimate contact with each other as when they are in the liquid state. For this reason, aside from the question of cost and convenience, solutions only are employed in electroplating.

ELECTRO-CHEMICAL ACTION

It was discovered many years ago that chemical and electrical phenomena are often coexistent, or at least closely related. Chemical action between certain metals, or carbon and a metal, when impressed in an acid, for instance, produces an electro-motive force between the two. This is the action of the ordinary primary battery. Water, when an electric current is passed through it, breaks up into its chemical components—hydrogen and oxygen. These are two simple examples of decomposition by electro-chemical action.

ELECTROLYSIS

Electrolysis is the term applied to the decomposition of substances by an electric current. To explain this decomposition, the molecule must be considered as disintegrating into smaller particles, each of which may consist of one or more atoms. These particles, called ions, may be assumed to have positive or negative electrical charges. These differently charged ions move in opposite directions. The ions moving toward the negative electrode or cathode are termed cations;

those moving toward the positive electrode or anode are called anions. The cations of bases and salts are, in general, the metals, while hydrogen is the cation of acids.

ELECTRO-DEPOSITION OF METALS

We now come to the application of the foregoing theory. Suppose an electrolyte is formed by dissolv-

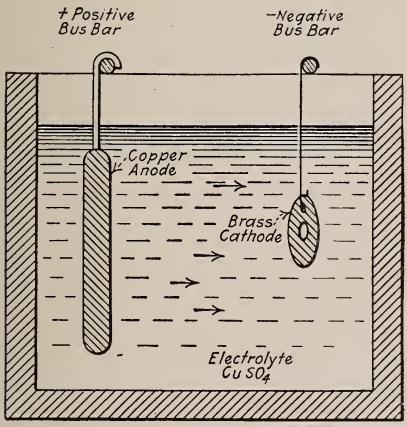

Fig. 1.—Simple Apparatus for Electroplating

ing copper sulphate in water. Into this solution is suspended, as shown in Fig. 1, a copper plate anode and any article of another metal—brass, for example. To the copper plate is connected the positive terminal of a direct current generator or of a battery; to the brass article, the negative terminal. The former plate is the anode, the latter the cathode. In a few moments a light coating of copper is deposited on the

brass article, the deposit increasing in thickness as long as the current flow continues and the anode remains. The explanation of this phenomenon is clear from the discussion in the preceding paragraph. The copper, Cu, in the copper sulphate solution is the cation and moves toward the cathode, depositing the copper as it gives up its charge. The SO_4 is the anion and moves to the anode to which it is attracted, where it chemically combines with the copper plate to form copper sulphate, $CuSO_4$. Thus, while the electrolyte is continually replaced, the anode disintegrates as it gives up the copper to the solution.

FARADAY'S LAWS

Two fundamental laws, set forth by Faraday, are of interest to the electroplater, and must be mentioned before passing on to another subject.

The first law states that the weight of any substance discharged at the electrodes in a given time is directly proportional to the quantity of electricity passing through the electrolyte. Thus, in the illustration just given of copper plating, if a certain amount of metal is deposited with one ampere flowing through the electrolyte, twice the deposit might be expected in the same time interval if the current were two amperes.

The second law may be summarized as stating that the amounts of the different substances deposited by a given quantity of electricity bear the same relation to each other as their respective chemical equivalents. The equivalent of any element in chemistry is the amount by weight which may replace or combine with one part by weight of hydrogen. Using again the simple illustration of water, H_2O might be expressed

hydrogen 2, oxygen 16. Thus the ratio is eight to one and eight is the chemical equivalent of oxygen. The equivalents of other elements are determined in like manner. The atomic weight, when divided by the equivalent weight, gives a number termed the valency of that element.

ELECTRICAL CONDUCTORS

The effect of the passage of electricity through an electrolyte is to decompose it. Quite different is the result of current flow through a metal conductor. Aside from an increase in temperature, there is no chemical or physical change in the metal.

THE ELECTRIC CIRCUIT

Before there can be a flow of electricity a complete circuit must be established. Such a circuit is indicated in Fig. 2, where it is compared with a simple

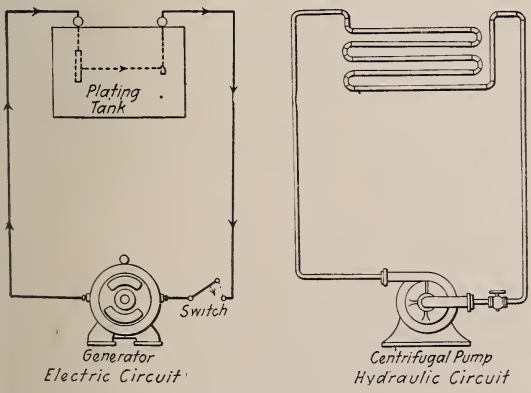

Fig. 2.—Comparison of Electric and Hydraulic Circuits

hydraulic circuit. The switch and stop-cock serve identical purposes; they control the flow of electricity and water respectively. The plating tank offers resistance to the flow of current in the electrical circuit, while a series of cooling coils, perhaps, retards the flow in the hydraulic circuit.

THE AMPERE

As an aid in defining the various units of electrical measurement, this analogy of the passage of an electric current through a wire and the flow of water in a pipe may again be cited. The quantity of water flowing through a pipe in a specified time is usually measured in gallons. In like manner the quantity of electricity flowing through a wire in a given period is expressed in amperes. The gallon and the ampere, then, are both units of quantity measurement. A more technical definition of the ampere is: "the practical equivalent of the unvarying current which, when passed through a solution of nitrate of silver in water (in accordance with standard specifications), deposits silver at the rate of 0.001118 gram per second." It is also interesting to note that in accordance with the second law of Faraday, this same current would deposit approximately 0.0003287 gram of copper in one second.

THE VOLT

Again referring to the water pipe illustration, the difference in hydrostatic pressure between two points in the system is expressed in pounds per square inch. In the electric circuit the difference in pressure, or potential, between two points is measured in volts.

POTENTIAL DIFFERENCE

Refer to Fig. 3, illustrating analogously the similarity between pressure drop and potential difference at various points in the system. When the stop-cock

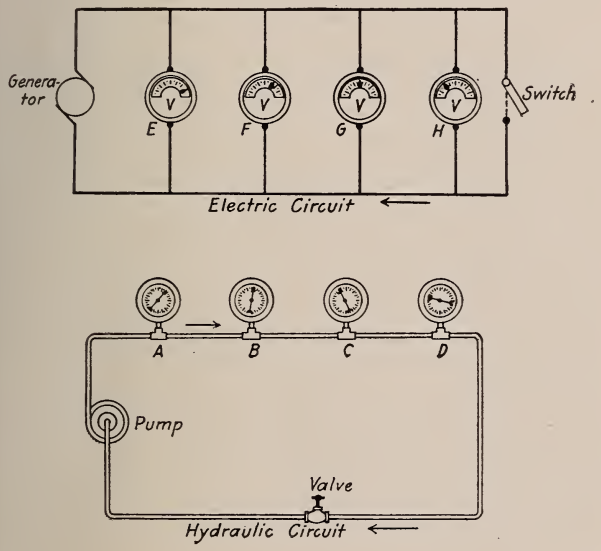

Fig. 3.—Fall of Potential and Fall of Pressure

is closed so that no water flows, the pressure gages all indicate the same reading. In like manner, the voltmeters in the electric circuit all show the generator terminal voltage when the switch is thrown, so that no current flows. Open the stop-cock, and a uniform drop in pressure is noted on the gages, A showing the highest reading and D the lowest. The same condi-

tions exist in the electric circuit; when the current is flowing, the voltmeter, F, indicates a lower reading than the meter E, G lower than F, and H the lowest of all. The difference between the readings at E and H is termed the difference of potential.

THE OHM

Because no substance is a perfect conductor of electricity, a percentage of the electric energy is changed during transmission to some other form, usually heat. This transformation is caused by the resistance the substance presents to the passage of the electric current. This resistance of any substance is expressed in units termed ohms and is definitely known by comparison with the standard measure of resistance. This standard unit or ohm is the resistance, at 0° Centigrade, of a column of mercury 106.3 cm. long, having a cross-section of 1 sq. mm.

RESISTANCE FACTORS

There are several conditions that influence the resistance of a conductor, such as material, cross-section area, length, and temperature. It is readily understood that the amount of resistance varies with the nature of the substance. Copper, for instance, is an excellent conductor of electricity. On the other hand, iron shows a resistance six times that of copper, while the resistance of mercury measures about sixty-four times as great. Electrical resistance also varies inversely as the area of the cross-section of the conductor. In the case of a round wire, the resistance varies inversely as the square of the diameter. This is seen at a glance by referring to tables showing wire sizes

and the corresponding resistances per unit length. Further, provided the material and cross-section of a conductor remain constant, the resistance varies directly as the length. This means that all other values being equal, a wire 50 feet long has twice the resistance of a section 25 feet in length. The fact that the resistance of a conductor changes as its temperature varies is of especial interest to the electroplater. Metals show an increase in electrical resistance when their temperature is raised. As exceptions to this law, carbon and electrolytes show a decrease in resistance to the passage of an electric current when the temperature is increased. This is why it is so essential to keep the plating bath at a comparatively high temperature by artificial heating.

There is a definite relationship between the resistance, current strength, and potential difference or electro-motive force, known as Ohm's Law. Expressed in the form of an equation, $I=E/R$, where I is the current strength in amperes, R is the resistance in ohms, and E is the electro-motive force in volts. Thus, it is readily seen that to increase the flow of current in an electric circuit, either the voltage must be increased or the resistance decreased. In plating work, the current is usually regulated by controlling the resistance of the circuit by a rheostat. This method is discussed in another chapter.

Other convenient forms of the first equation are: $E=IR$, i.e., the electro-motive force, is equivalent to the product of the current value in amperes and the resistance expressed in ohms.

$$\text{Or, again, } R=\frac{E}{I}$$

If any two of the three values are known, the third is easily computed through the use of the foregoing equations.

SERIES CIRCUITS

When several resistance units, such as R_1, R_2, and R_3, are connected in series as indicated in Fig. 4, the total resistance of the three units is the arithmetical sum, or $R_1+R_2+R_3$. Obviously, the current has the same value at any part of the circuit, since there is

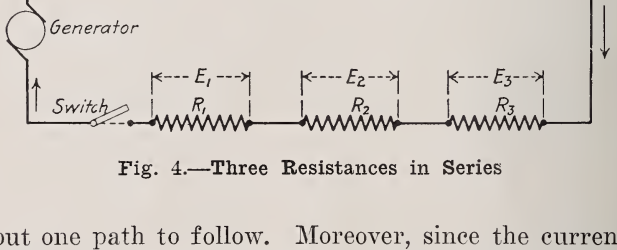

Fig. 4.—Three Resistances in Series

but one path to follow. Moreover, since the current flowing through all units is identical, then the difference of potential across each unit is directly proportional to its resistance. For example, $E_1=R_1I$, or $E_3=R_3I$. Note that if a break occurs at any point in the circuit, the current flow through all units ceases.

PARALLEL CIRCUITS

On the other hand, if the resistance units are connected in parallel or multiple, as shown in Fig. 5, the total resistance is not the sum of the three, nor do the currents flowing through the different units have the same value. Parallel circuits are of espe-

cial interest to the electroplater, since the tanks he uses are in reality resistance units connected in the circuit as indicated in Fig. 6.

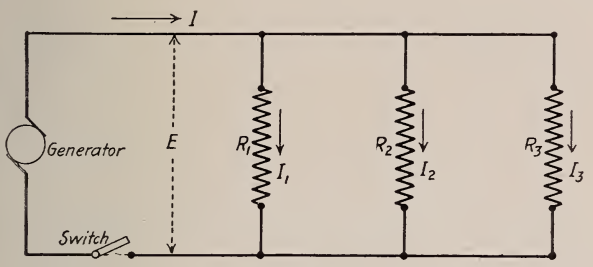

Fig. 5.—Three Resistances in Parallel

Let us consider the subject through the assistance of equations. I is the total current generated and E is the line voltage. By referring to the diagram

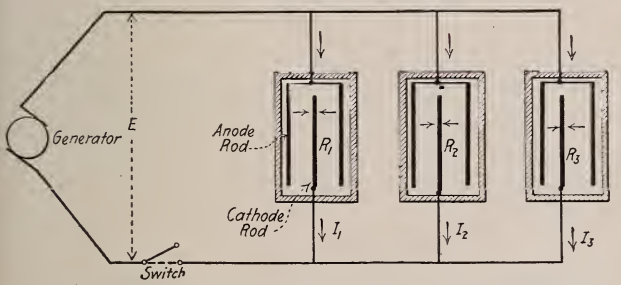

Fig. 6.—Three Plating Tanks Connected in Parallel

again, it is noted that the potential difference across any unit is E, regardless of the resistance. The value of E, then, is the constant in all of the following

equations. The resistance of the three units may be considered as R_1, R_2, and R_3, while the value of the current flowing in each is I_1, I_2, and I_3, respectively. R is the total resistance, which is, of course, less than that of any of the individual units.

Then $$I=\frac{E}{R}$$

But $$E/R=E/R_1+E/R_2+E/R_3$$

Eliminating E, we find the reciprocal of the resistance, termed the conductance, is

$$1/R=1/R_1+1/R_2+1/R_3$$

The equation may be used in this form, but it is usually more convenient to complete it. Thus,

$$R=\frac{R_1+R_2+R_3}{R_1R_2+R_2R_3R_1+_3}$$

Should it so happen that all of the units had the same resistance as R_1, for instance, then

$$R=\frac{R_1^3}{3\,R_1^2}=\frac{R_1}{3}$$

Knowing the resistance of any unit, it is a simple problem to determine the current flowing in that branch:

$$I_1=\frac{E}{R_1}$$

Again, using a voltmeter and an ammeter, the value

of E and I_3, for example, are quickly found. And

$$R_3 = \frac{E}{I_3}$$

Note that disconnecting any one or two of the resistance units in parallel or multiple does not open the complete circuit; only the current value increases in the remaining branch or branches.

THE COULOMB

That quantity of electricity which, when passed through a silver nitrate solution, deposits 0.001118 gram of silver, is termed one coulomb. This definition is, perhaps, more easily understood when it is stated: a coulomb is the quantity of electricity produced by one ampere flowing for one second.

THE JOULE

The unit of work is the joule. It is the work done per second by one ampere flowing through a circuit under a pressure of one volt. In other words, the product of the current in amperes, potential difference in volts, and the time in seconds, is expressed in joules.

THE WATT

The watt is the power developed by one joule per second, i.e., one volt-ampere. The kilowatt, or 1,000 watts, is usually employed in commercial measurement of power.

It is interesting to note the several methods of

determining the power developed in a circuit. If W is taken as the symbol for the watt, then

$$W=EI$$

But in a preceding paragraph it was learned that

$$I=\frac{E}{R}$$

Hence, $$W=E\times\frac{E}{R}=\frac{E^2}{R}$$

Or again, $$E=IR$$

Thus, $$W=I\times IR=I^2R$$

This last equation is quite important and is often used to determine the power lost in the form of heat in a circuit whose resistance is known.

THE WATT HOUR

Because the joule is too small a measure of electrical energy, a larger unit, the watt hour, is employed. The kilowatt hour is used commercially in the measurement of electric power. The term is self-explanatory and requires no definition.

THE HORSE-POWER

Power-producing engines or motors are usually rated by their horse-power capacity. Mechanically the horse-power is equivalent to lifting 550 pounds a distance of one foot in one second, or 33,000 foot-

pounds per minute. One horse-power is equivalent to 746 watts. This conversion factor, 746, is important, since generator capacity is usually expressed in kilowatts, and to determine the horse-power of the driving unit the conversion factor is employed.

CHAPTER III

THE LOCATION AND CONSTRUCTION OF THE PLATING ROOM

Three Factors—The Individual Shop—The Factory Department — General Requirements — Floor Plan — Generator Location—Floor Drainage—Wooden Floor Construction —Acid Proof Walls—Ventilation—Illumination—Heating.

THREE FACTORS

In these days of keen business competition, the success of any enterprise depends, in a large measure, upon the site of operations, upon efficient equipment, and upon contented, loyal employees. The electroplating industry is no exception; efficient management will demand these as prerequisites. The first two factors may be discussed here, but the third is a personal issue, and therefore not within the province of this book.

THE INDIVIDUAL SHOP

If an electroplating business is to be successful, the shop must be so located that prospective customers can reach it without undue effort or expense. It is not necessary to secure a site in the congested business section where high rents prevail, but a location approximately equidistant from all of the sources of trade is advisable. Facilities for handling large quantities of commercial work should include, aside

from the plating and polishing operations, adequate space for storage, packing, and shipping. Again, providing for the future, sufficient floor area for business expansion should be secured.

THE FACTORY DEPARTMENT

Even though the plating room be but a department in a large factory, the same attention to its location in relation to the other divisions is necessary. Study the machining operations which precede the plating work; consider the routing of each part that must pass through the plating and polishing rooms. For instance, if it is observed that the final machining operations on the major portion of the factory output is that of drilling or counter-sinking holes, endeavor to locate the plating and drill-press departments in close proximity. Perhaps, on the other hand, it is found that most of the small punch press parts pass through the plating room before being sent to the assembly floor or finished parts storeroom. Should these punched parts outnumber the articles coming from other departments, then the obvious location for the plating division is in the direct path from the punch shop to the assembly floor or storeroom. Such elimination of trucking saves both expense and production time.

GENERAL REQUIREMENTS

Since it is often quite difficult to prevent leaks in the floor, even though it is carefully waterproofed, a ground level location is suggested. Good natural lighting increases the efficiency of the workmen and incidentally prevents eye-strain. A further factor

pertaining to the welfare and health of the operator is fresh air. If it is not possible to utilize large roof ventilators, resort must be had to motor-driven fans for the removal of poisonous fumes from the atmosphere. A water, steam, and compressed-air supply should be available, if possible. Further discussion of this last point will appear later.

FLOOR PLAN

Obviously, it is not possible to present a definite floor plan of a plating room equipped to meet all the varied requirements of the trade. The plater must study his business needs and outline the equipment accordingly. A suggested plan, however, is shown in Fig. 7. This indicates two nickel tanks, one zinc tank, a copper and a brass tank, as well as two plating barrels. These latter are used to advantage for plating small articles, such as screws, nuts, and washers. The tanks are, of course, adapted to larger work. Vats for gold and silver plating may replace any of those mentioned, or, if necessary, may be added to the group. The cleaning and scouring boards are centrally located to minimize walking distance. The dips are situated across the room from the tanks, so what fumes may escape from the ventilating hood will not affect the men working at plating. Articles removed from the dip may be plunged in the hot water, dried in the sawdust, and placed in the oven without retracing steps.

GENERATOR LOCATION

The generator should be placed as near as convenient to the plating tanks. The essential reason

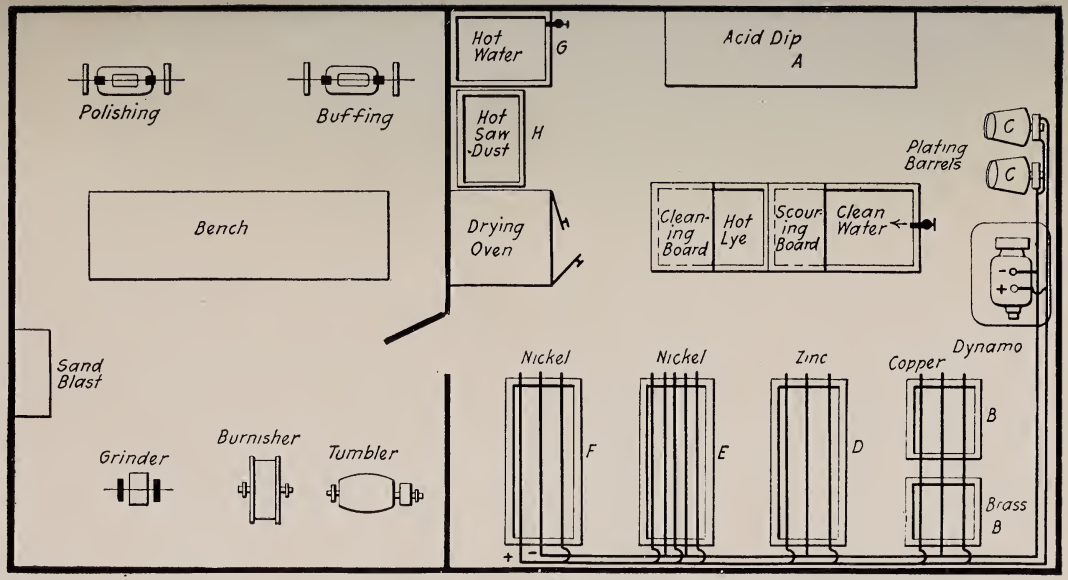

Fig. 7.—Suggested Floor Plan for Plating and Polishing Room

for this is to prevent a drop in potential or voltage between the generator and the tank rods. A further result of this will be the saving in the cost of the heavy copper conductors. Under no circumstances should the machine be located in the grinding or polishing rooms, unless the bearings and commutator are fully protected from the gritty dust which is usually floating in the air. Indeed, if space will permit, it is advisable to install the generator outside the plating room. The acid fumes, even though the windings are impregnated, often attack the insulation. It must be remembered that the generator requires a certain amount of attention if satisfactory results are to be obtained; an inaccessible location, such as the ceiling, should not be chosen.

FLOOR DRAINAGE

Upon the floor construction depends the health of the employees; a damp, poorly drained walking surface is the cause of much discomfort. If possible, a concrete surface should be laid with a slight slope toward a central tile drain. This concrete surface need not be more than five inches thick at the heaviest point, nor more than two inches at the drain. If it is essential that no moisture leak through any possible cracks that may form, further precautions are necessary. Two layers of a good roofing paper should first be laid, the strips of the first layer at right angles with those of the second. Several coats of asphaltum paint between the layers, as well as upon the top surface, are required to make an acid and moisture proof seal.

WOODEN FLOOR CONSTRUCTION

While the concrete work just described may serve as a floor surface, much greater satisfaction results from the use of an additional wooden platform, such as is shown in Fig. 8. Since the tank and vat foundations rest directly upon the concrete base, it is only necessary to provide the superstructure for the spaces

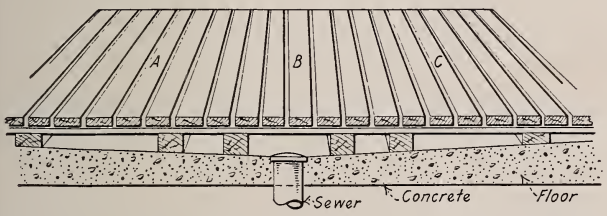

Fig. 8.—Cross Section, Showing Floor Construction of Plating Room

between them. These small platforms, such as A, B, C, are approximately 5 feet square. The small dimensions are suggested, since the sections may then be quickly and easily removed at any time for cleaning or repairing work. The platform is not solid, but is constructed of heavy slats, thus allowing spilled water or acid to pass through to the concrete base where it flows to the drain. The advantage of this type of floor is apparent; it gives the electroplater the driest possible walking surface.

ACID PROOF WALLS

If it is desired to protect the lower walls of the plating room from acid and water stains, a protection

similar to that indicated in Fig. 9 is suggested. This consists of a wooden frame-work standing four or five feet high and about two inches from the wall. It is covered with roofing paper, the lower edge turned with the slope of the floor as shown, to throw the acid or

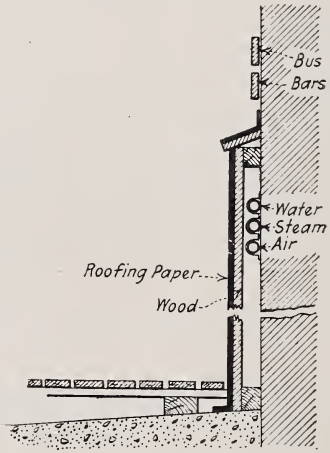

Fig. 9.—Cross Section, Showing Framework for Protecting Wall of Plating Room from Damage by Acid

water toward the drain. If the framework and the dipping or pickling tanks adjoin each other, several coats of asphaltum paint are required to serve as a further protection against acid. It is a good plan to install the air, steam and water pipes behind this structure. On the other hand, it is not advisable to pass any electrical circuits through the space thus provided, since they should be as accessible as possible.

VENTILATION

Undoubtedly, there is nothing quite so priceless as good health, and the electroplater is cautioned against endangering this asset by working in a room filled with poisonous fumes. Advantage should, of course, be taken of natural ventilation through windows and roof openings. If possible, the movement of the air

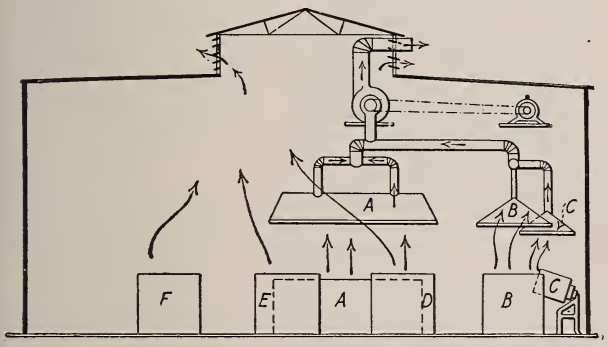

Fig. 10.—Natural and Forced Ventilation. Hoods are Placed Over Tanks A, B, and C. Refer to Fig. 7

should be accelerated by the use of power-driven fans. Over all tanks or vats whose contents give off objectionable vapors, hoods should be suspended and the fumes collected by these hoods drawn off through sheet-metal pipes by a ventilating fan. The hoods are usually constructed of sheet iron, but wood can be used. Several coats of asphaltum or other acid-resisting paint should be applied as a protection from chemical action. In the ventilating system shown in

Fig. 10, a hood, A, is placed over the dipping vats, one, B, over the copper and brass tanks, and another, C, above the plating barrels. The fan and the driving

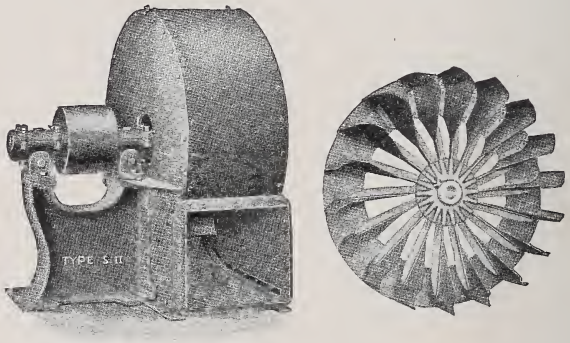

Fig. 11.—Exhaust Fan for Forced Ventilation
(Mott Sand Blast Mfg. Co.)

motor should be located as near to the outlet as possible. Either or both can be suspended from the ceiling or secured to wall supports.

ILLUMINATION

The electroplater is often so interested in studying modern plating methods and so intent upon improving the electrical and tank equipment, that a very important item escapes his attention. This item is proper illumination, without which efficient and perfect work cannot be accomplished. During the summer months it is seldom necessary to supplement daylight with artificial illumination. For winter, or on a foggy, cloudy day, there are many hours when

the electric light is required. At night, of course, artificial illumination is a necessity.

There is, perhaps, but one suggestion to be made on the use of daylight. If the tanks be located so

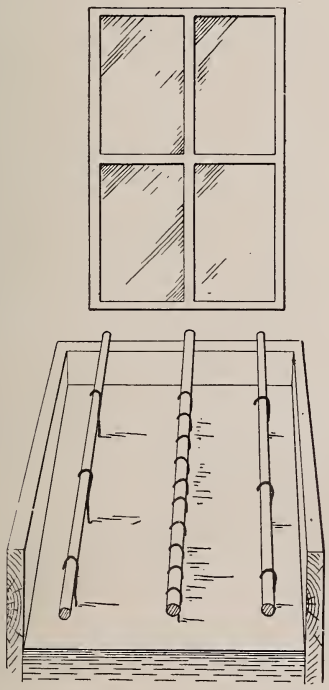

Fig. 12.—Natural Lighting. Note the Relative Location of Tank and Window

that the cathode rods lie at right angles with the plane of the window, it follows that the plater, while working, will never stand in a position to cast his shadow over the tank. Furthermore, no equipment

should be placed in such position as to screen the light or throw a shadow on the plating work. Note, in Fig. 12, the correct relative position of tank and window.

With artificial lighting the tank location is not as important as the position of the lamps. A quantity of correctly spaced lamps of low candle power is

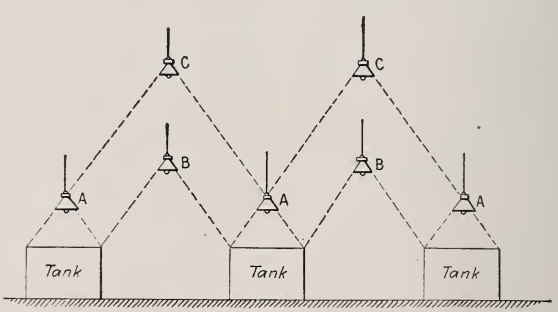

Fig. 13.—Artificial Lighting, Showing Correct and Incorrect Lamp Spacing

much to be preferred to a single large unit. The latter prevents concentration, since the eyes involuntarily fix themselves on the bright spot; moreover, with a high candle power lamp, the shadows are denser and, therefore, misleading. If it is not possible to suspend a light above each tank or bench, the units should be equally spaced and hung above the working plane. By referring to Fig. 13, the meaning of this will be apparent. While the lamp B, hung just above the head of the workman, provides little illumination for the tanks, C allows light for both tank and floor, and also eliminates distracting shadows. A height of

12 to 14 feet above the floor is usually found to be best.

HEATING

Because of the presence of acid vapors in the plating room, the air is changed many times a day through the use of some type of ventilating system. During the cold winter months the heating problem, because of the need for the excessive ventilation, is a serious one. Obviously the best solution is to add more heating units, whether they be steam radiators or stoves. Again, if arrangements are made so that the incoming cold air is admitted where the fumes are heaviest and the exhaust strongest, the remaining part of the room is then comparatively free from draughts.

CHAPTER IV

ELECTRICAL EQUIPMENT FOR THE PLATING ROOM

Current Supply—The Generator—The Electro-Magnet—The Field Magnet — Four Types — Series Generator — Shunt Generator—Compound Generator—The Separately Excited Shunt Generator—The Armature—The Commutator—The Armature Winding—The Brushes—The Bearings—Capacity—Location—Driving Unit—Motor Capacity—Motor Speed—Generator Voltage Regulation—Generator Field Rheostat — The Ammeter — The Voltmeter—The Amperehour Meter—Tank—Rheostat—Two-Wire System—Three-Wire System.

CURRENT SUPPLY

Modern plating methods do not include the use of the primary battery as the chief source of the electric

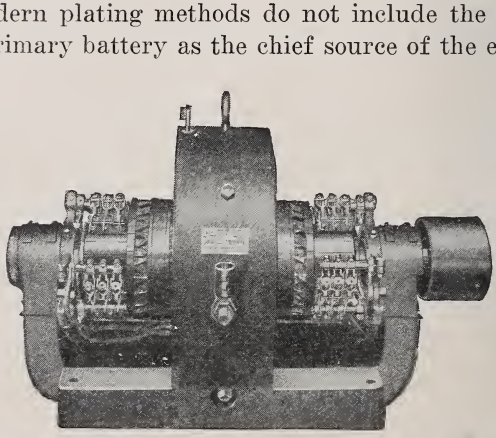

Fig. 14.—1500 Ampere, 6 Volt Plating Generator

(Bennett O'Connell Co.)

current supply; the more reliable and efficient power-driven generator has replaced it. The chemical battery, except for quite small shops or for experimental work, is no longer considered in the planning of plating equipment, and therefore no space will be given here to a discussion of the existing types.

THE GENERATOR

A well-designed and carefully constructed generator is, perhaps, expensive, yet the plater can ill afford to purchase a machine which, though cheap,

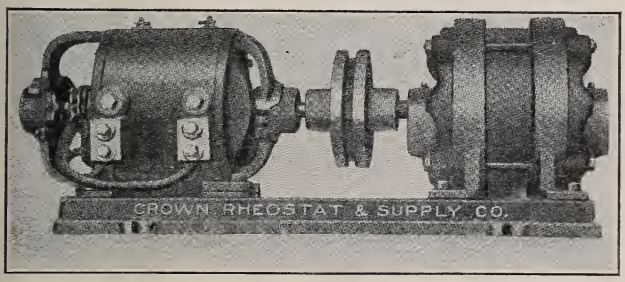

Fig. 15.—Direct Connected 300 Ampere, 6 Volt Plating Generator

(Crown Rheostat & Supply Co.)

is fabricated from inferior material and by questionable mechanics. Careful consideration should be made of the requirements, and these then compared with the advertised characteristics of the generators on the market. Too much caution cannot be exercised in making the selection, for upon the uninterrupted service of the machine depends the success of

the output. Should the generator fail every plating operation must necessarily cease, while the overhead expense of the shop continues. It is advisable, therefore, to consider carefully the construction, char-

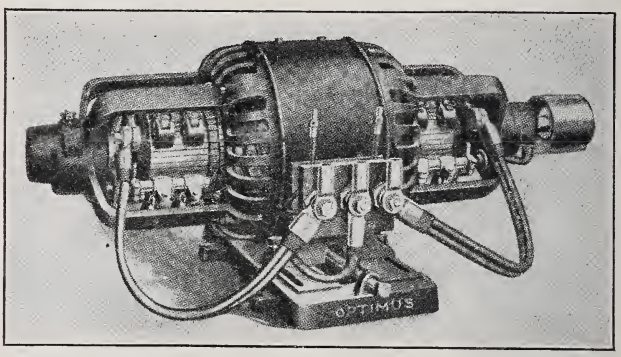

Fig. 16.—Double Commutator Generator. Capacity: 750 Amperes at 6 Volts or 375 Amperes at 12 Volts.

(A. P. Munning & Co.)

acteristics, and operations of the several types of generators. The illustration in Fig. 15 shows a direct connected 300 ampere plating generator and that in Fig. 16 outlines a double commutator generator for large current output.

THE ELECTRO-MAGNET

Undoubtedly the best method of approaching a description of the generator is to briefly review the elementary principles of the electro-magnet. The hardened steel horseshoe magnet is a familiar toy to all of us. Similar magnetic properties are given to

a soft iron rod, around which a wire, carrying an electric current, is wound. The polarity of the solenoid or electro-magnet is dependent upon the direction of current, and is determined by so grasping the

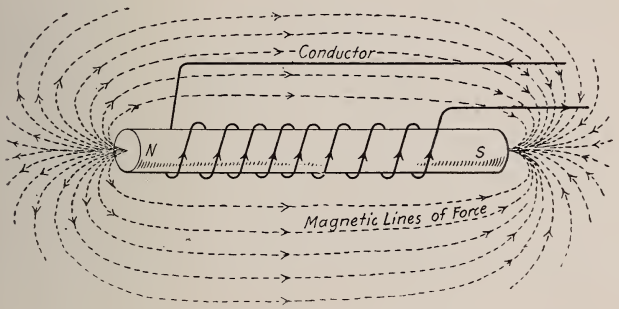

Fig. 17.—Electro Magnet, Showing Direction of Current Flow in Winding and Resultant Polarity

coil of wire with the right hand, that the fingers point in the direction the current is passing. The north pole of the solenoid is then at that end of the rod toward which the outstretched thumb, at right angles to the fingers, is pointed. This method is known as the "right hand rule." Note Fig. 17.

THE FIELD MAGNET

The field magnet of a dynamo is quite similar to the solenoid just described. A four-pole generator, for instance, might be constructed from four electro bar magnets, the ends of which have been formed as in Fig. 18. The adjacent placing of the like poles

produces four poles instead of eight. A more convenient and less costly method of construction is employed, however, in commercial practice. A circular

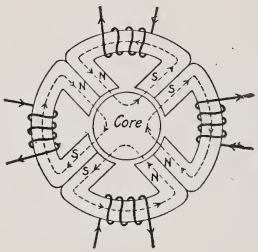

Fig. 18.—Four Solenoids Bent and Placed Together to Form a Four Pole Dynamo Field

or rectangular iron yoke is provided with poles, the wire being wound on the latter, as indicated diagram-

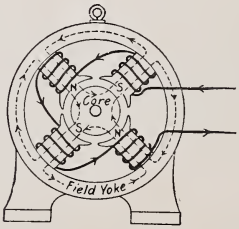

Fig. 19.—Field Winding and Magnetic Circuit of Dynamo

matically in Fig. 19. Any number of poles in multiple of two may, of course, be provided to agree with the design.

FOUR TYPES

In general, there are four types of direct current producing dynamos, or more exactly termed generators, and these take their names from the method of field winding or excitation. These types are: Series, shunt, compound, and separately excited shunt.

SERIES GENERATOR

The stator or field of a series generator has a low resistance winding, since the full line current passes through it. It is, therefore, usually wound with a few turns of heavy copper wire or strip. Since the

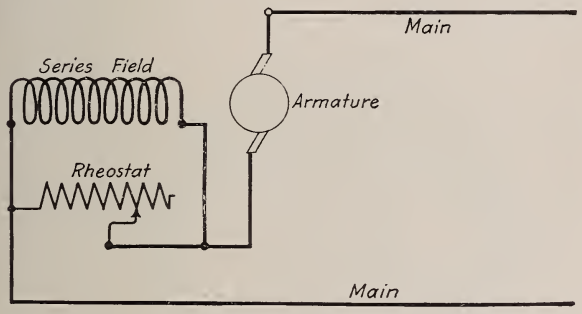

Fig. 20.—Connections for Series Generator

current regulation of a generator is mainly dependent upon its field excitation, a variable resistance is placed in parallel with the field winding, as shown in the conventional diagram, Fig. 20. However, on account of the very large current required for plating work, the series type generator is seldom specified for such use.

SHUNT GENERATOR

As the name implies, the field winding of the self-excited shunt type generator is shunted or paralleled with the line circuit. Of necessity, this winding must have comparatively high resistance, and therefore a large number of turns of fine wire is wound

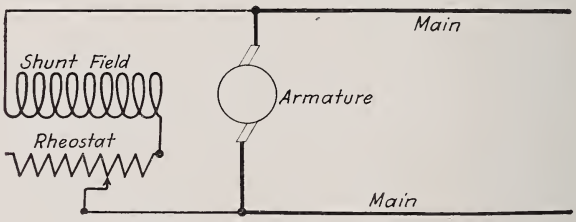

Fig. 21.—Connections for Shunt Generator

on the field magnets. To adjust the field current, a variable rheostat is connected as indicated in Fig. 21. Since so small a percentage of the current output of the generator is required to excite the field, the rheostat need not have the capacity required for the series type machine. The shunt generator, when the driving speed does not vary, maintains an almost constant voltage. It is, therefore, used for plating when the output required is small.

COMPOUND GENERATOR

Where plating currents of 2,000 amperes or less are required, the compound wound generator usually proves most efficient. It retains the desirable features of both the shunt and series winding. A shunt winding is employed and its terminals connected, through

a rheostat, to the brushes. Over this is wound a few turns of heavy wire or metallic strips, which are

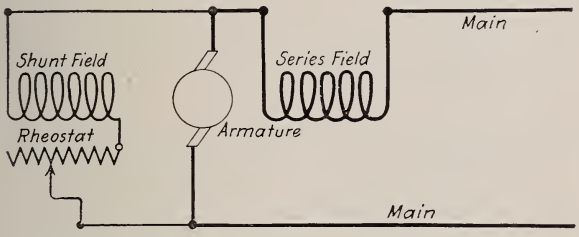

Fig. 22.—Connections for Compound Generator

connected in series with the line circuit. Fig. 22 shows this in conventional form. The voltage regu-

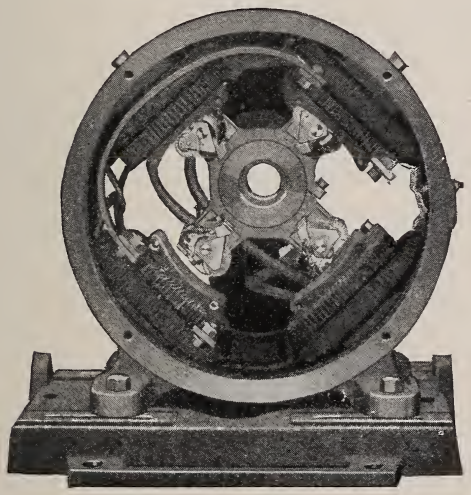

Fig. 23.—Generator Frame, Showing Field Coils and Position of Brush Holders. Compound Wound

(Crown Rheostat & Supply Co.)

lation of this machine is accomplished with less difficulty than is that of the shunt type. Even though the current output varies, as is often the case when work is placed in or removed from the tanks, an approximately constant voltage is obtained, provided the driving speed does not vary.

THE SEPARATELY EXCITED SHUNT GENERATOR

Generators, designed and built to deliver a current output in excess of 2,000 amperes, are usually of the shunt type, the field coils being connected to a separate source of direct current supply. Quite often a

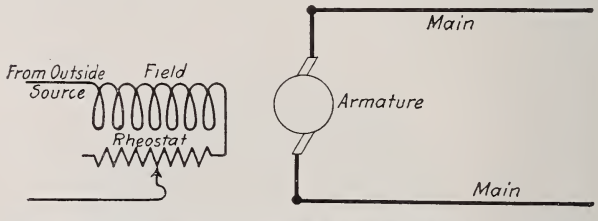

Fig. 24.—Connections for Separately Excited Generator

small generator, driven by the same unit that turns the larger machine, is employed. The field excitation is regulated in much the same manner as that previously described for the shunt generator. Note Fig. 24.

THE ARMATURE

The armature is that part of the generator which rotates within the magnetic area produced by the field magnets. No space can be given here to all of the interesting fundamental principles involved in the production of an e.m.f. Briefly, when a wire is

passed through a magnetic field so that it cuts the lines of force at right angles, an e.m.f. is set up between the ends of the wire. Thus, if a wire is mounted on a drum, as indicated in Fig. 25, and the latter revolved between the field magnets, a current flows in the wire or circuit each time it passes a pole

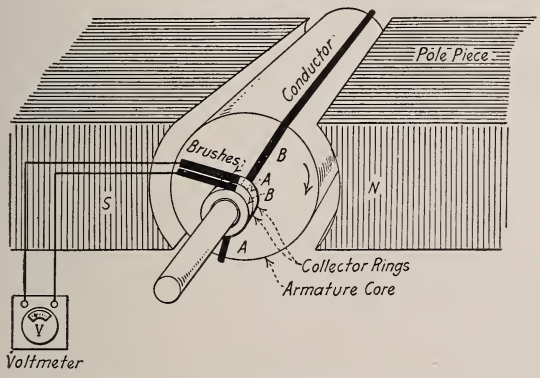

Fig. 25.—Single Conductor, Each End Connected to Individual, Insulated Metal Collector Ring

where it cuts the magnetic flux. If the ends of the wire are connected to two simple metallic rings, which are insulated from each other and from the shaft, so that connections may be made through brushes to a two-way voltmeter, a strange thing is noticed. When the armature wire passes the north field pole, the voltmeter pointer swings in one direction, but quickly reverses, passes the zero point, and swings an equal distance in the opposite direction as the south pole magnet is approached and passed. This voltmeter movement clearly indicates that the direction of current flow in the armature coil is dependent upon the

polarity of the pole past which the wire is rotated. If current pressure readings could be taken for each degree of the complete cycle, as indeed they may be with special experimental apparatus, the plotted e.m.f. curve might appear similar to that shown in

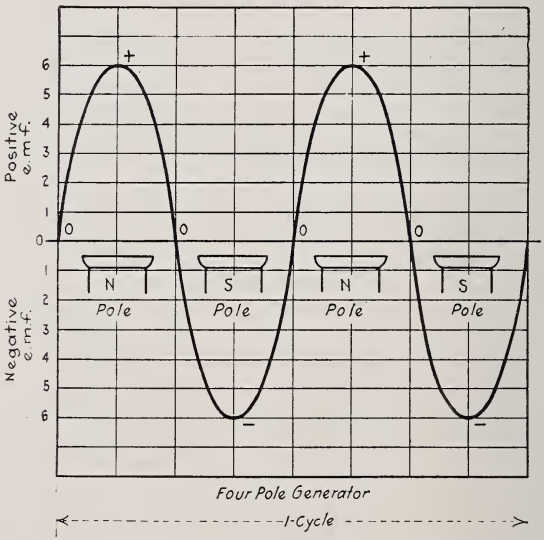

Fig. 26.—No Commutation: Alternating Current

Fig. 26. For electroplating work, alternating currents cannot be employed, since a uni-direction current is necessary to carry the metal ions toward the cathode only. A later paragraph will discuss a method of securing positive current values.

In general, the generator armature is constructed from an assembly of three units: the shaft, the spider, and the core iron. The shaft is, of course, turned

from high grade steel. Its length and other dimensions are determined by the design of the generator. The core iron is punched from thin sheets of iron having special magnetic characteristics. The thin laminæ are slotted to receive the armature coils, and insulated to a certain degree by painting to prevent eddy currents in the assembled core. The core iron is placed over the machined cast-iron spider, where it is bolted tightly in position. In this assembly precautions are taken to provide for ventilating ducts whose function it is to prevent overheating. The spider and core assembly are finally pressed on the shaft.

THE COMMUTATOR

In plating work, alternating current, such as that just described, cannot be used; the current must flow

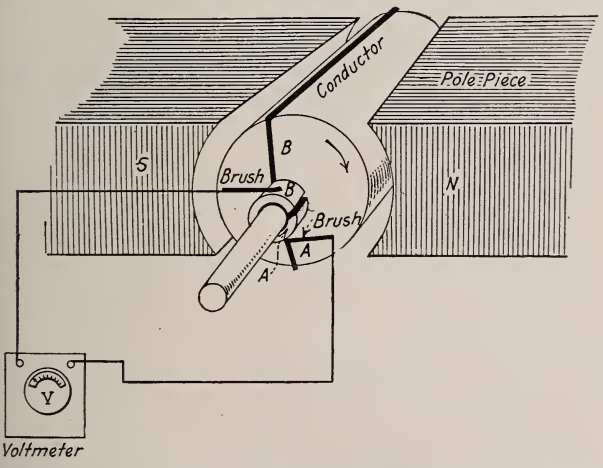

Fig. 27.—Single Conductor, Each End Connected to Separate, Insulated Commutator Segment

in one direction only. Thus, instead of slip rings for collecting the current, a device to commutate or change the current direction at the moment it is about to become negative in value is employed. A commu-

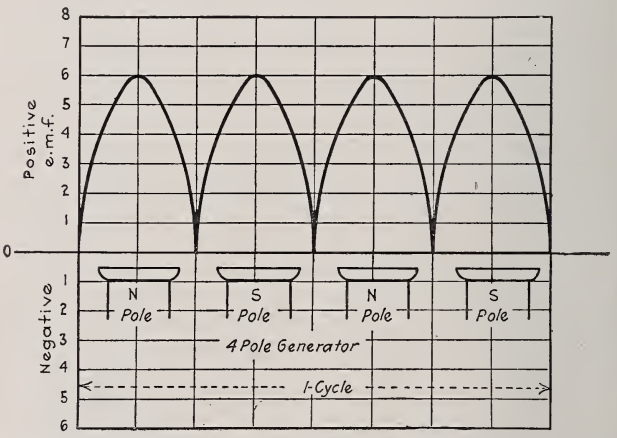

Fig. 28.—The Effect of Commutation is to Produce Direct Current

tator for a single circuit, as shown in Fig. 27, would be in but two sections, thus allowing the brushes to interchange their connections with the rings at the points where reversals of current are about to take place. The addition of a commutator changes the e.m.f. curve of Fig. 26, so that only positive values are given as in Fig. 28.

Obviously, the e.m.f. generated by a single wire is insufficient for practical purposes. Hence, the modern dynamo has an armature wound with a great many wires. A large number of such active wires

are so connected that their voltages are accumulative. Again, since the wires are evenly distributed about the drum, or armature core, the commutator is constructed of many segments which are connected to the winding at regular intervals. This allows an

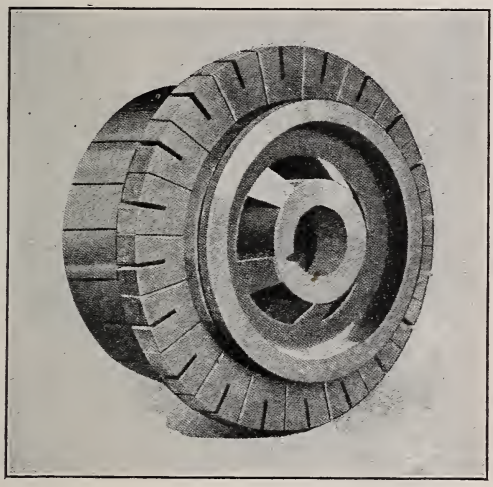

Fig. 29.—Commutator Assembly

(Bennett O'Connell Co.)

almost constant voltage across the brushes, ironing out, so to speak, the humps in the curve of Fig. 28, and giving an approximately straight, horizontal voltage line.

The commutator is usually built up of especially formed copper segments, insulated from each other by mica pieces. The mica and copper segments are held rigidly together by heavy iron flanges pressed in position. This construction is shown in Fig. 29.

THE ARMATURE WINDING

The armature conductors are usually formed of heavy copper strip insulated with a cotton covering. There are several types of windings used for generators, and for a further discussion the reader is

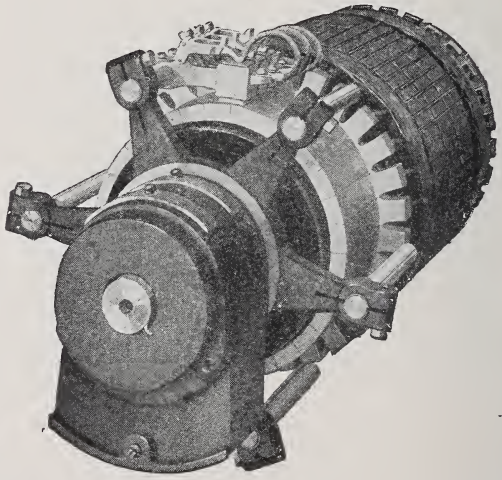

Fig. 30.—Brush Rigging and Armature Assembly
(Bennett O'Connell Co.)

referred to the many available texts on dynamo design. Before the windings are placed in the slots, the latter are usually insulated with cloth and paper of high electric strength. Often wooden or fiber slot wedges are used to securely lock the coils, preventing their movement when the armature revolves.

THE BRUSHES

There are as many brushes as poles, and in practice they are usually set slightly in advance of the

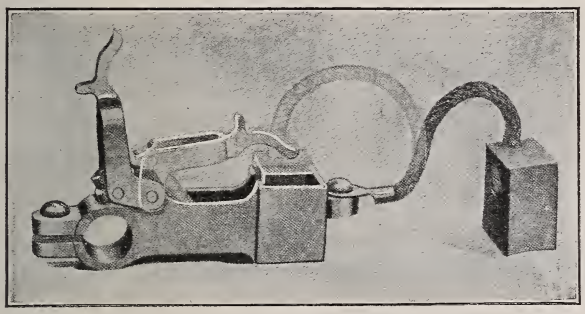

Fig. 31.—Brush Holder and Brush

(Bennett O'Connell Co.)

latter. Specially designed brush holders, similar to that shown in Fig. 31 are provided. Because of the low voltage required in plating work, low resistance

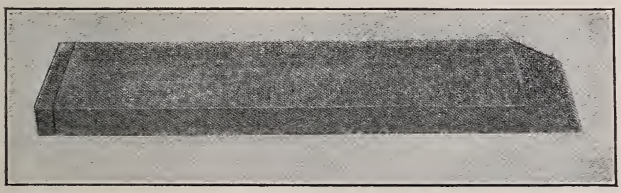

Fig. 32.—Woven Wire Brush for Plating Generators.

(Hanson & Van Winkle Co.)

brushes are essential. Carbon has a high resistance, and is therefore not a suitable material for such brushes. Metallic composition brushes, however, of

which there are several types on the market, appear to give excellent results. A typical woven wire brush for plating generators is shown in Fig. 32.

THE BEARINGS

Most modern generators are equipped with bronze or other non-frictional metal bearings. Lubrication is effected by means of oil rings revolving on the shaft, the lower section of the rings being suspended in oil. Ball bearings are often used on small machines with success.

CAPACITY

Generator manufacturers are usually glad to consider the particular requirements of the plater, and to offer suggestions concerning the capacity and type of machine required to meet his needs. It, of course,

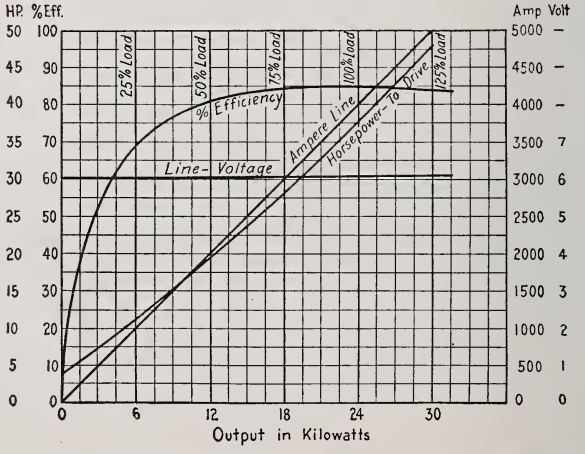

Fig. 33.—Performance Curve of 24K.W. Generator: 6 Volts, 4000 Amperes, 700 r.p.m.

(A. P. Munning & Co.)

must be remembered that there is no economy in purchasing a generator to care for only the present demand. An extra tank or two may be required in the near future to meet business expansion, and the increase in first cost for the larger machine capacity will then be fully repaid. A performance curve of a 24K.W. generator is given in Fig. 33 to show efficiency at various outputs.

LOCATION

As soon as the new generator is uncrated, a detailed examination should be made to discover what damage, if any, was caused during transit. Should all parts prove to be in perfect mechanical condition, place the generator upon the foundation previously prepared for it, bolting it down securely. If the machine is large, the foundation should be of concrete. Small generators may be supported on bridge work above the heads of the workmen. As has been previously stated, it is best to locate the generator and driving unit outside the plating and polishing rooms. Quite often a convenient space is found in a store room, office, or passageway adjoining the plating room. Because of the low potential and the cost of copper conductors, the generator should not be located more than fifteen or twenty feet from the tanks. All motors and generators installed in the plating room should have their windings protected from the acid fumes by treatment with an impregnating compound.

DRIVING UNIT

The generator may be belted to an engine, a power line shaft driving other machines, or an individual

motor. Except in isolated shops, electric power is now available, and engine drive requiring additional attention is becoming unpopular. There are many occasions when the generator is the only machine requiring power. At such times the long line shafting and belting to other machines must be in motion,

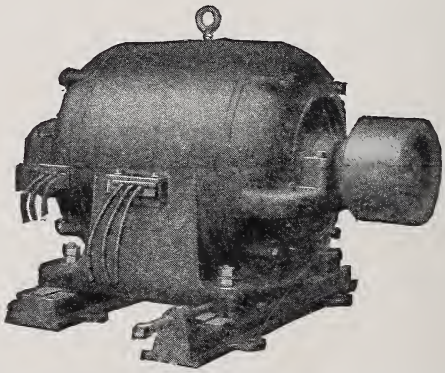

Fig. 34.—A Three Phase Alternating Current Motor.
(Wagner Electric Mfg. Co.)

with resulting friction losses and waste of power. The modern electric motor requires little attention, is efficient, easily controlled, and may be maintained at slight cost. Obviously, then, individual motor drive should be chosen by the electroplater. A three phase alternating current motor, suitable for plating shop power, is illustrated in Fig. 34.

MOTOR CAPACITY

The size and speed of the driving motor for any generator may be quickly calculated. It is remem-

bered, from an earlier discussion, that the output of a direct current generator is measured in watts, the product of amperes and volts. Should this product in watts be divided by the conversion factor 746, the result is then expressed in horse-power. Suppose, for instance, it is desired to ascertain the motor capacity required to drive a generator whose name-plate indicates it is capable of a delivery of 1,500 amperes at 6 volts pressure. Thus the generator output is 9,000 watts, or, divided by 746, 12.06 h.p. But to choose the driving unit some account must be taken of the electrical and mechanical losses in the generator, counter shaft, and belts. A very safe estimate of the losses would be 25% of the generator capacity. Thus the driving unit must develop 15.07 h.p. A standard 15 h.p. motor would, accordingly, be specified.

MOTOR SPEED

Any motor speed can be selected, provided the pulleys on the counter shaft and generator are of such diameter as to drive the latter at the speed marked on the name-plate. It must be well understood that the generator speed cannot vary. Should speed indicator readings show any considerable variations, efficient plating work cannot be expected. If the driving unit is to be a direct current machine, it should be a shunt wound, as this type operates at a constant speed. Before starting up the motor, examination should be made to insure that the connections are such that the generator armature revolves in the correct direction; that is, the commutator turning away from the brushes.

GENERATOR VOLTAGE REGULATION

Voltage regulation is of the utmost importance in electro-deposition; an unchanging current flow of known value allows the plater to correctly determine the length of time required to produce a given deposit before the work is placed in the tanks. While the current flow is regulated at each tank by individual rheostats, it is nevertheless advisable to maintain a constant and normal line pressure. The terminal voltage of a generator depends upon the speed at which it is driven as well as the field excitation. Since the speed seldom varies, the true voltage must be held constant by increasing or decreasing the generator field excitation. This is easily accomplished by decreasing or increasing the resistance of the field circuit through the aid of a rheostat. The usual rheostat connections can be seen in the conventional diagrams, Figs. 20, 21, 22 and 24.

GENERATOR FIELD RHEOSTAT

A rheostat is a simple device so arranged that, by manipulating a handle, electrical contact is made with any division of a number of series-connected resistance units. These resistance units may be special alloy metal ribbons, or of wire wound on bobbins. A field rheostat is often subjected to heat from the resistance units, and the insulation is therefore usually of fireproof material.

THE AMMETER

Efficient work of any nature can only be accomplished when the workman is dealing with known

quantities. For this reason the plater produces better results when he knows definitely the current passing through any tank. An ammeter is used for this purpose. There are several types available for use with direct current, but the so-called D'Arsonval galvanometer construction is most generally employed. A pivoted bobbin of wire is held between the poles of

Fig. 35.—Ammeter

a permanent magnet. A light pointer is fastened to the bobbin in such manner that, when the latter is deflected by the magnet, the free end of the former swings over a divided scale. The scale divisions are calibrated to represent amperes, and the value of the current flowing in the bobbin winding is indicated by the deflection of the needle. An instrument of this nature is shown in Fig. 35.

The windings of the ammeter coils cannot carry the heavy line current required for plating work. An

ammeter shunt, of known resistance, is therefore used; this allows only a known small percentage of the line current to pass through the meter. The ammeter scale is, however, calibrated to show the total amperes flowing through the external shunt and meter coil combined. When the meter has once been calibrated, the same shunt must always be used; otherwise a new

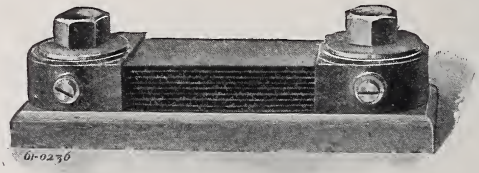

Fig. 36.—External Shunt for Ammeter

(Wagner Electric Mfg. Co.)

calibration must be made with another accurate instrument as a standard. Ammeter shunts and leads are furnished with the instrument, the latter being considered as a part of the meter circuit. External shunts are furnished only where large currents are to be measured; instruments for currents of small value are equipped with a shunt in the ammeter case. A typical ammeter shunt for use in the external circuit is shown in Fig. 36.

THE VOLTMETER

A voltmeter is an instrument employed to indicate the current pressure. In construction it is quite similar to the ammeter with the exception that the

internal resistence is high instead of low. Hence the voltmeter may be connected directly across the line yet the current passing through it is practically negligible. A single voltmeter may be employed to indi-

Fig. 37.—Voltmeter with Connections for Serving Six Tanks

cate the potential difference of several tanks provided the required connections are made by the aid of switches. Such an arrangement is shown in Fig. 42, where one voltmeter is connected to serve six tanks.

THE AMPEREHOUR METER

In the past, the usual method of determining the weight of metal deposited on the articles undergoing electroplating was to note the lapse of time and the

average current flow. The product of these two, or the ampere hours, might then be used to calculate the quantity of metal deposited. Competition and the rising cost of materials have made it necessary to

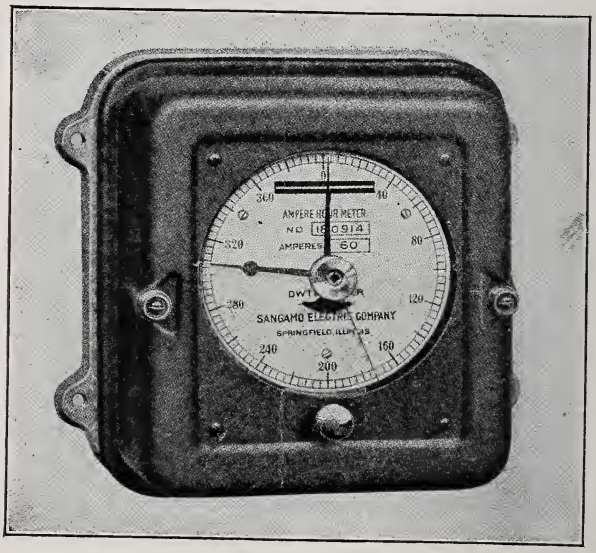

Fig. 38.—Amperehour Meter for Controlling Electroplating Operations

(Sangamo Electric Co.)

eliminate waste in the deposition of metals. The use of the amperehour meter allows the plater to deposit only the predetermined amount of metal. The control of plating operations, with an instrument such as that illustrated in Fig. 38, is briefly explained by the manufacturer as follows:

"The standard meter has a dial reading in any desired unit weights of the metal with which the meter is to be used; for example, dwt. of silver, grains of gold, pounds of copper, etc. The meter is equipped with a movable pointer, operated by a knob in the middle of the glass window over the dial, so that the pointer can be set at the amount of metal desired for any particular plating operation. For

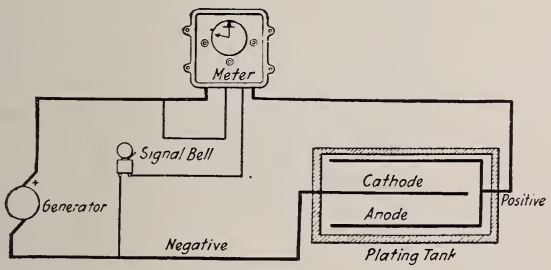

Fig. 39.—Connections for Amperehour Meter

example, if twelve dozen spoons were to be silver-plated and required 100 dwt. of silver, the indicating pointer would be set at 100 on the dial, after which the large moving hand, operated by the mechanism of the meter, would be set at the zero point. As the current passes through the meter, the large hand moves in a clockwise direction around the dial until it reaches the pointer, in this case set at 100 dwt., when contact is made against a pin in the adjustable pointer, thus operating through auxiliary leads to an electric light or bell, as a signal." The external connections for the amperehour meter are shown in Fig. 39 and can be easily understood.

TANK RHEOSTAT

As was explained in Chapter II, the quantity of current flowing in any one of a number of parallel circuits is dependent upon the resistance of that

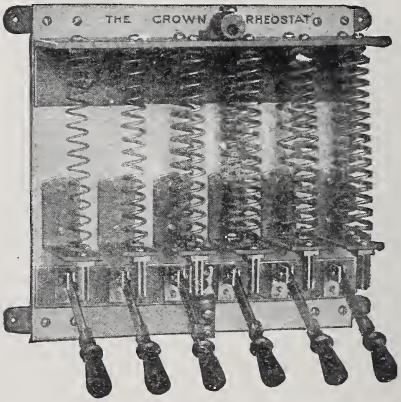

Fig. 40.—Tank Rheostat: Knife Switch Type

branch. This condition is duplicated in the case of a number of multiple-connected plating tanks pre-

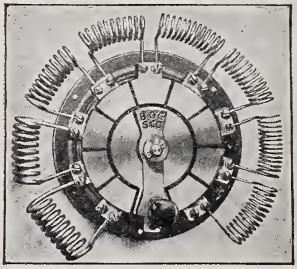

Fig. 41.—Twelve Spring Dial Type Rheostat

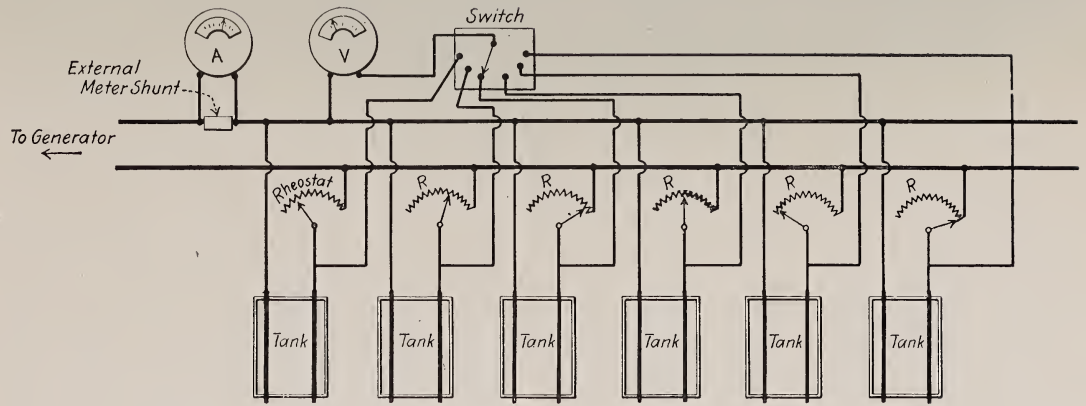

Fig. 42.—A Two Wire System: Ammeter and Voltmeter Connections

senting various resistances to the flow of current. It is obviously impossible to place equal quantities of work in each tank to balance the resistances. A rheostat may be furnished, however, for each tank which, being connected in series with it, serves to regulate the voltage and thereby the current. Figs. 40 and 41 indicate types of tank rheostats so arranged that the e.m.f. can be regulated to a fraction of a volt.

TWO WIRE SYSTEM

The most simple method of forming connections for the plating tank is indicated in Fig 42. This might be termed a two-wire system. Only two supply wires, or bus bars, positive and negative, are provided.

THREE WIRE SYSTEM

In recent years the three wire, or multiple voltage, system of distribution has come into favor. The standard plating dynamo is usually wound to produce a current pressure of six volts. There are many classes of work, however, which require voltages somewhat above six. In response to the demand for greater flexibility, specially designed, two commutator, double voltage generators are available. When wired, as shown in the diagram, Fig. 43, with neutral, positive, and negative supply lines, any voltages up to 12 are obtainable. For the usual run of work the 6-volt current is employed; when higher voltages are desired, the switch is thrown to the 12-volt supply line. Tank rheostats regulate the intermediate voltages. This system is particularly useful where high voltage barrel plating is employed part of the time.

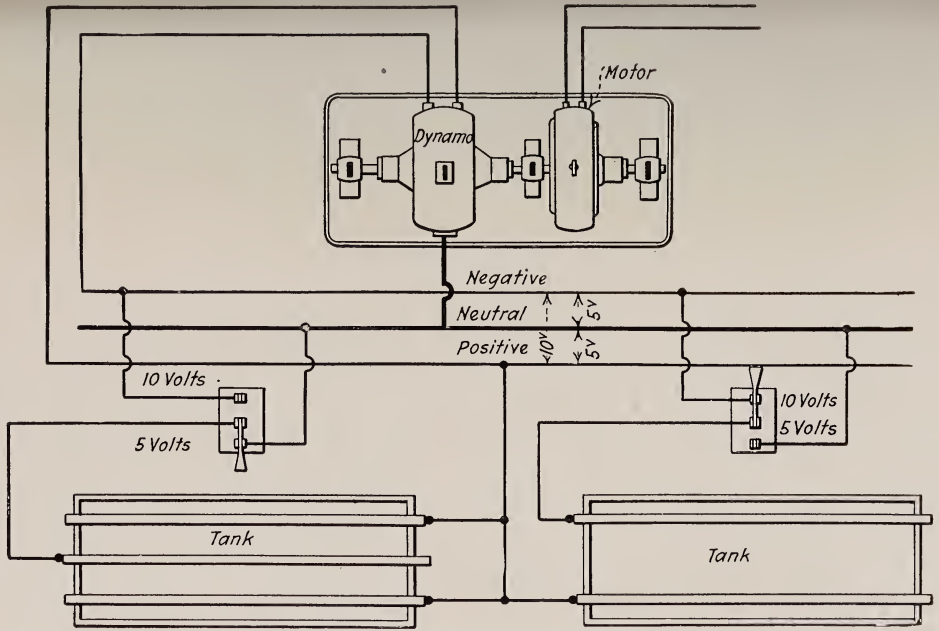

Fig. 43.—Method of Wiring for Multiple Voltage System

CHAPTER V

ELECTROPLATING TANK EQUIPMENT

Tank Capacity—Three-Types of Plating Tanks—Still Tanks—Earthenware Tanks—Steel Tanks—Wooden Tanks—Tank Construction—Advantage of Warm Plating Baths—Steam Coil Heater—Insulating Joint—Regulating Valve—Solution Agitation—Agitation with Air—Tank Rods—Plumbing—Rotating Plating Barrels—Automatic Plating Machinery—Automatic Moving Tank—Principal Advantages—General Design—Other Types—Tanks for Preparatory Processes—Pickling Tanks—Bright Dipping Tanks—Special Ventilating Hoods—Lye and Potash Tanks—Hot Water Tanks—Scouring Tanks.

TANK CAPACITY

Plating-room efficiency is, in a large measure, dependent upon the size, type, and location of the solution tanks. A study of the type of work required and the daily production necessary to maintain the desired schedule, will provide a basis for an estimate of the necessary tank capacity. It is better to have a portion of an extra tank idle than to crowd a few with work. A safety margin providing for equipment breakdowns is well worth the added investment.

THREE TYPES OF PLATING TANKS

There are three main types of plating tanks. The most important and generally used type is the still tank which is merely a steel, earthenware, or wood vat in which neither the solution, anodes, or cathodes

move during the plating process. Small articles in quantities may be quickly plated in the second type, a rotating barrel. There are several kinds of these mechanical plating tanks, but in all cases the articles tumble over each other as the deposition process continues. The third general type is the automatic plating machine. Usually, with this device, the work is cleaned, plated, washed and dried without any assistance from the operator. A more detailed description of these general types will be considered in the following paragraphs.

STILL TANKS

Vats or tanks for electrolytic or other solutions, are constructed of earthenware, metal, or wood. In capacity they usually range from four gallons upward.

EARTHENWARE TANKS

Because earthenware tanks are somewhat fragile, they are not often used where another type can be substituted. They are, however, especially useful for holding acid and cyanide solutions. Hydrofluoric acid, since it attacks clay compositions, cannot be used in an earthenware tank. Stoneware vats may be used with all solutions except hot sulphuric acid and hydrofluoric acid. If proper care is exercised to see that they do not crack, these tanks will last indefinitely, there being no appreciable disintegration.

STEEL TANKS

Steel tanks are available in many forms. The welded steel container presents the best appearance,

since there are no seams or rivets visible. Usually the seams are closed by oxy-acetylene welding, the material thus added increasing the strength of the metal bond. Riveted and caulked joints also give good service but the possibility of leakage is always present. Boiler steel, approximately $\frac{3}{16}$ inch in thickness, is used in the construction of the average steel vat. Unlined, they make excellent containers for hot water, lye, potash, and cyanide solutions.

Fig. 44.—Electric Welded or Steel Riveted Tank
(Bennett O'Connell Co.)

When the inside surface is prepared with an acid-proof paint or asphaltum, they may be utilized for plating tanks. Enamel-lined iron containers are especially recommended for cyanide solutions, gold and silver electrolytes, lacquers, and other non-acid solutions. The enamel lining, however, chips easily if struck a sharp blow. An electrically welded tank with riveted top is shown in Fig. 44 and a chemically enamelled iron tank is depicted in Fig. 45.

WOODEN TANKS

Most popular of all types is the wooden tank. Inexpensive and easily constructed, it always finds favor in the plating room. Such containers may be purchased, made to dimensions desired by the electroplater. When an asphaltum or other lining is speci-

Fig. 45.—Chemically Enameled Iron Tank for Gold, Silver, Cyanide Solutions, and Lacquers

(Crown Rheostat & Supply Co.)

fied, it is usually applied after the delivery of the tank, since the continuous jarring during transit cracks a lining applied at the factory. Lead-lined tanks are more serviceable; but the added expense often causes the prospective purchaser to choose the cheaper painted coating.

The wooden tank is by no means difficult to construct, although a certain knowledge of wood working is, of course, essential. There is a satisfaction in building one's own equipment, aside from the material saving in the cost.

TANK CONSTRUCTION

Although the tank may be built in any desired dimensions, in general it should be about twice as long and nearly as high as it is wide. For instance, 7

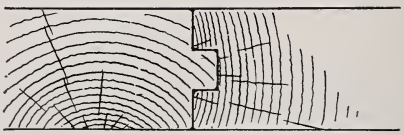

Fig. 46.—To Obtain a Tight Fit the Edges of the Boards Should Be Grooved

feet long, 3½ feet wide and 3 feet high gives a well-proportioned tank for fairly large work.

If possible, kiln-dried cypress lumber should be secured, 2 inches thick and 10 to 12 inches wide. After deciding what are to be the dimensions, the

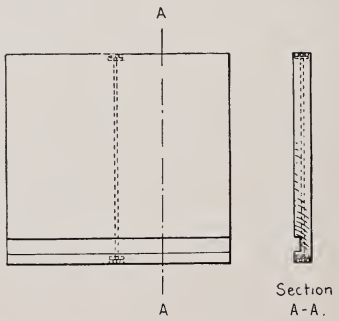

Fig. 47.—End Boards Assembled, Showing Grooving for Bottom Pieces

two end-board assemblies should be constructed, the edges of the boards being grooved, as shown in Fig. 46, so that they fit together tightly. Temporary cleats may be nailed across the boards to hold them together until the final set up. Two inches from the bottom edge of each of the end-board assemblies, a groove, ¾ inch deep and as wide as the thickness of the lumber to be used for the tank bottom, is cut,

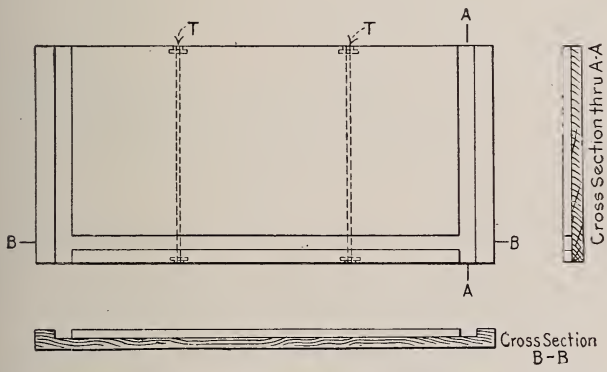

Fig. 48.—Side Boards Assembled and Grooved to Match Bottom and End Pieces

as indicated in Fig. 47. In cutting all the grooves necessary in constructing this tank, the greatest care must be exercised to produce a neat, tight fit. A loose joint necessarily causes leaks.

In a similar manner two side-board assemblies are made ready. By referring to Fig. 48, it is seen that three grooves are cut, one for each end piece, and one for the bottom boards. Each groove is cut 2 inches

from the end or edge of the boards, as the case may be.

As soon as the bottom boards are cut to correct length and matched together, the general assembly is made. Thoroughly treat all grooves with the acid-proof paint prior to this final operation. If the several pieces match perfectly, arrange to hold them securely in place with several steel tie rods.

For a tank of average size, four tie bolts at each end and seven along the bottom are sufficient. If the

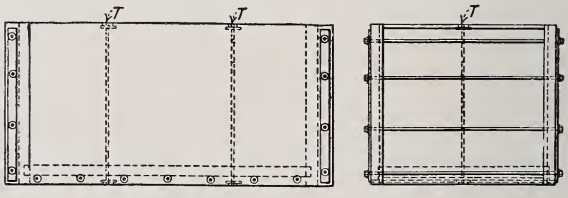

Fig. 49.—Front and Side Views of Wooden Plating Tank. Note That the Bottom and Sides are Matched Into Each Other

tank is to be lead-lined, the number may be decreased. The bolts are made of $\frac{3}{8}$ inch diameter steel rods cut to the correct length and threaded at each end. For the bottom bolts, iron washers may be placed next to the wood, but for the end rods iron plates are provided, one inch wide, $\frac{1}{4}$ inch thick, and of sufficient length to span all of the side boards. Holes are drilled in these plates through which the tie rods or bolts may pass. Tighten all the nuts to the greatest possible extent without stripping the threads. This will draw all joints together. If it is seen that the

several boards, when assembled for the side and end pieces, do not match perfectly, or have a tendency to separate, further precautions must be taken. Bore ¼-inch holes through the several boards at right angles to their length and parallel to their width. Tie bolts passed through the boards can then be used to draw them together. The letter T denotes these special bolts in the illustrations in Fig. 49, which

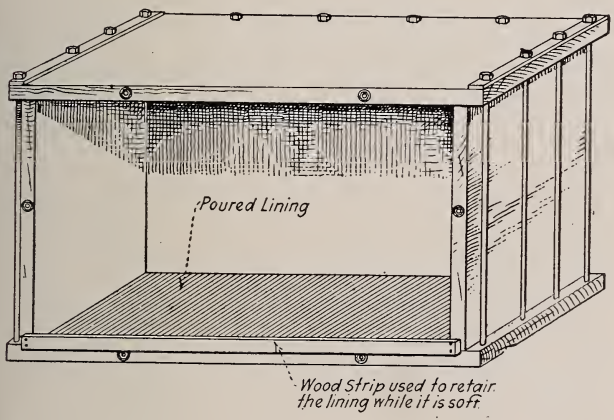

Fig. 50.—Method of Pouring Tank Lining

shows front and side views of a conventional wooden plating tank.

Lining the tank with lead sheeting is difficult, and an inexperienced workman will not find it easy work to fuse together the seams. An asphaltum, or other prepared tank lining, can be applied with much greater success and at less expense. First paint the

inside tank surface with a thin coating of the prepared lining. As soon as it is dry, spread over this painted portion a coarse grade of cheese cloth, tacking it down at several points to insure a smooth surface. Several heavy coats of the lining material are then painted over the cloth, the latter acting as a reinforcement to prevent cracking or flaking of the prepared surface after it is dry. Time should, of course, be given between paint applications to allow the previous coating to harden.

Another method of lining the tank which is quite satisfactory might also be suggested. Lay the tank on its side. Tack a strip of wood along the outer edge of the downward side, as is indicated in Fig. 50. Using a carpenter's level, adjust the tank with great care so that the downward side is perfectly level. When all is thus prepared, pour in the lining material until it settles over the surface to the desired depth. As soon as the poured surface is hard, turn the tank to the opposite side and repeat the process. When all four sides are treated, turn the tank right side up and pour in a slightly heavier layer for the bottom. Prepared tank lining material is often inflammable, and it is therefore best to heat or mix it in the open air or where there is no fire hazard.

ADVANTAGE OF WARM PLATING BATHS

One of the many puzzling phenomena is that the resistance to the flow of current through a metallic conductor increases with the rise in temperature of that conductor, while just the opposite is true in the action of plating solutions. An increase in the tem-

perature of the electrolyte results in a decrease in electrical resistance. It is therefore seen that it is to the advantage of the plater to use warm solutions. During the summer months artificial heat is not required, but on cold winter days the temperature of the plating bath must be maintained constant and above 50° F., if satisfactory work is to be expected.

STEAM COIL HEATER

A steam coil laid on the bottom of the tank or, as indicated in Fig. 51, at one end, is sufficient to heat the solution. The last mentioned U-shaped coil is perhaps the most simple to construct. A one-inch

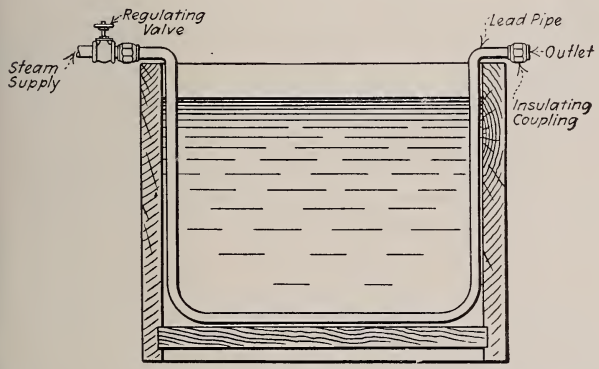

Fig. 51.—Steam, Passing Through a Lead Pipe Submerged in the Electrolyte, Supplies the Required Heat

lead pipe is cut to the correct length and formed to fit the tank. Each end is connected with an insulating steam joint or coupling.

INSULATING JOINT

Insulating joints are required to prevent the leakage of electric current from the tank circuit through

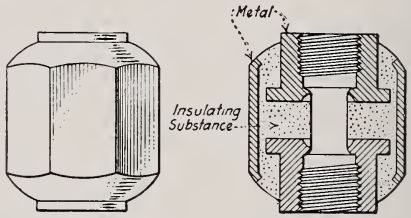

Fig. 52.—Insulating Joint or Coupling for Steam or Air Pipes. Used to Prevent Leakage of Electric Current Through Piping System

the piping system. A cross section of such a joint is shown in Fig. 52. They can be purchased in sizes ranging from ¼ to 1½ inch with standard threads.

REGULATING VALVE

For convenience in regulating the temperature, a steam pressure adjusting valve should be inserted on the inlet side of the steam coil.

SOLUTION AGITATION

During the process of plating, tiny gas bubbles form on the anodes. The effect of these bubbles is to decrease the active area of the positive plate, thereby increasing the resistance to the flow of current to the electrolyte. Unless the bubbles are removed by some exterior means, a more concentrated plating solution must be used to counteract the detrimental effect of the small anode area. Solution agi-

tation is, therefore, often employed, with the result that a fine, close-grained deposit is obtained with a low current density.

AGITATION WITH AIR

While mechanical agitation is, perhaps, the most effective method available for tank work, the special machinery is not only expensive but it often utilizes valuable space. On the other hand, compressed air agitation is simple and the system may be constructed

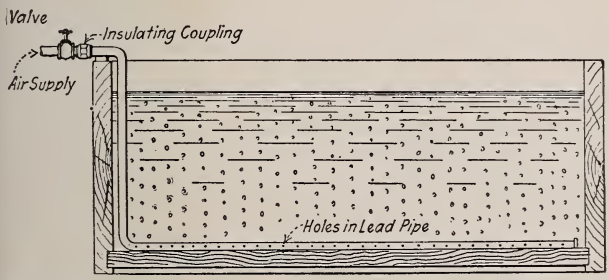

Fig. 53.—Cross Section of Plating Tank, Showing Agitation of Solution by Bubbles of Compressed Air Released From Perforations in Lead Pipe Laying on Bottom of Tank

and installed in a few hours time. Compressed air is available in most shops of average size, and certainly if the plating room is a department of an industrial plant. It is only necessary to drill a large number of small holes in a length of one-inch lead pipe, sealed at one end. This pipe is then laid along the center line of the bottom of the tank, as shown in Fig. 53, the free end passing up over the tank edge where it is connected, through an insulating joint and

regulating valve, to the air supply. The tiny bubbles of escaped air pass upward through the solution, effectively agitating it.

TANK RODS

While installing the heating coils and agitation system, it is well to keep in mind the location of the bus bars or tank rods for the anodes and the plating work. When the tank is used almost exclusively for plating large articles, one cathode rod is placed along

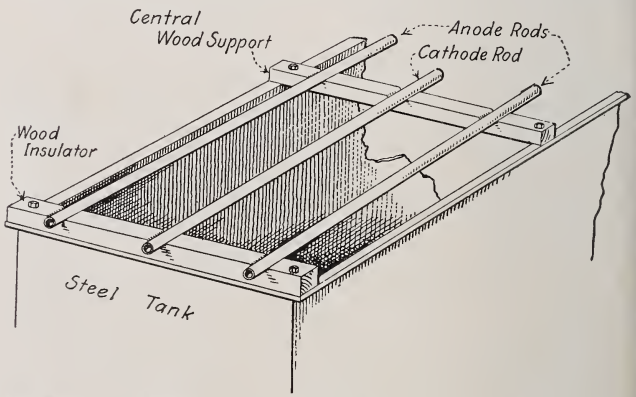

Fig. 54.—Wood Insulators for Anode and Cathode Rods Used With Metal Tank

the center line of the tank with an anode rod on either side. The cathode should always be provided with an anode on each side to equalize the plating action. Thus, if two cathode bars are placed to a tank, there should be three anode rods, and so on. If the plating tanks are constructed of metal or of wood lined with lead, it is necessary to provide an insulator, such as a block of wood, to prevent the rods

coming in contact with the metal. Such a provision is shown in Fig. 54. The anode and cathode rods must not only be of sufficient size to carry the heavy plating current, but to support as well the weight hung upon them. A copper rod can safely carry the

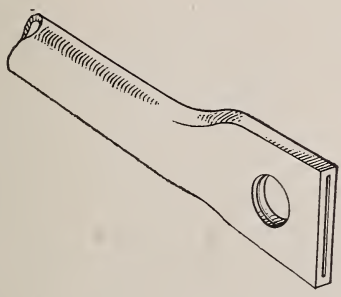

Fig. 55.—End of Anode or Cathode Tube Flattened and Drilled to Make Electrical Connection by Bolting to Supply Bus Bar

current but not the weight; a thin brass tube may carry the weight, but its capacity as an electrical conductor may be below the particular requirements. As a general rule, a brass or copper tube with a wall of liberal thickness answers most requirements. The plater should, of course, consult a table of values and sizes before making the installation.

Since low voltage is necessary for plating work, the greatest care must always be exercised to see that every electrical connection is perfect. There are few such connections which can be soldered, and bolting is, therefore, relied upon to make a tight contact. To assist in making these connections, each anode and cathode rod or tube is flattened at the connector end, and drilled to match the bolt hole in the bus bar.

Note Fig. 55. The electrical connections and distributing systems are described in another chapter.

PLUMBING

As soon as the various plating tanks are placed in a permanent position, the plumbing should be so arranged that each container is provided with a faucet directly over it, thus allowing the plater to fill the tank with water without effort or inconvenience.

Fig. 56.—Stringing the Work for the Still Tank. This Method is Slow and Tedious

(Hanson & Van Winkle Co.)

ROTATING PLATING BARRELS

As has already been intimated, the quickest and cheapest method of plating large quantities of small

articles is the mechanical rotating barrel. In appearance it is not unlike the familiar tumbler used in cleaning metal castings or tarnished punchings. A metal plate, fastened to the inside bottom of the

Fig. 57.—Modern Methods Permit Quantity Production. Loading a Plating Barrel With Small Work.
(Hanson & Van Winkle Co.)

barrel, is connected, through a collector ring on the outside bottom, to a brush contact with the negative bus bar. The anode is suspended from a steel arm and is stationary, while the barrel rotates. Articles placed in the barrel make electrical contact with the negative base plate and, as they tumble over each

other, the plating process continues. This tumbling action insures a uniform deposit of metal upon each article. One of the great advantages of this type of

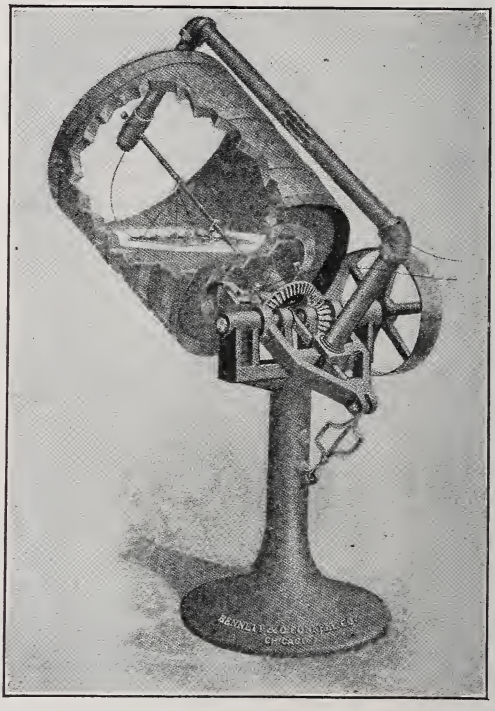

Fig. 58.—Tilting Type Rotary Plating Barrel Showing Position of Anode

(Bennett O'Connell Co.)

plating tank is that any piece of work can be conveniently removed for inspection without stopping the machine. The entire batch of work is removed

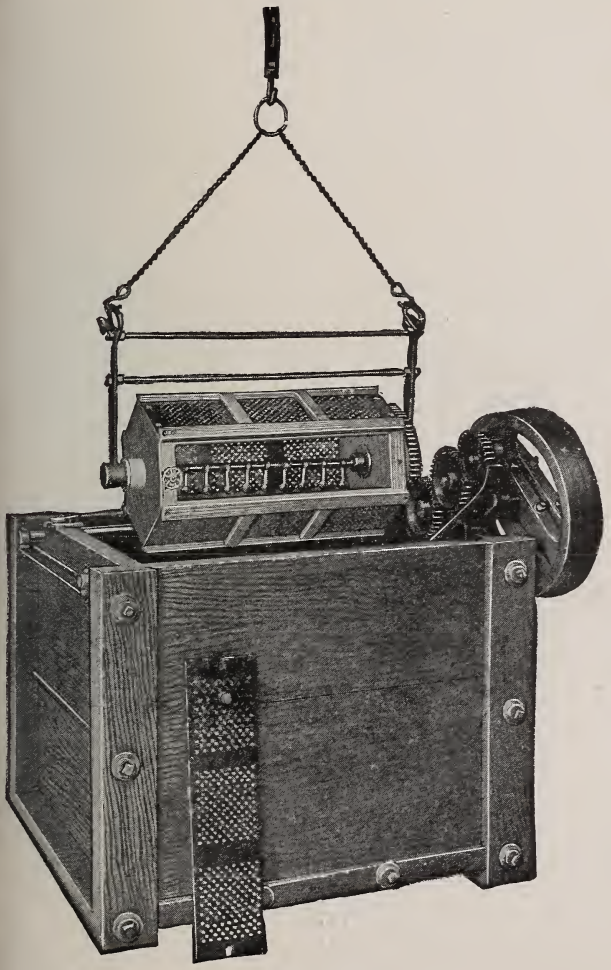

Fig. 59.—Rotating Plating Tank: Container Raised for Refilling

(General Platers' Supply Co.)

by scooping or by dumping. Fig. 58 illustrates this modern plating barrel.

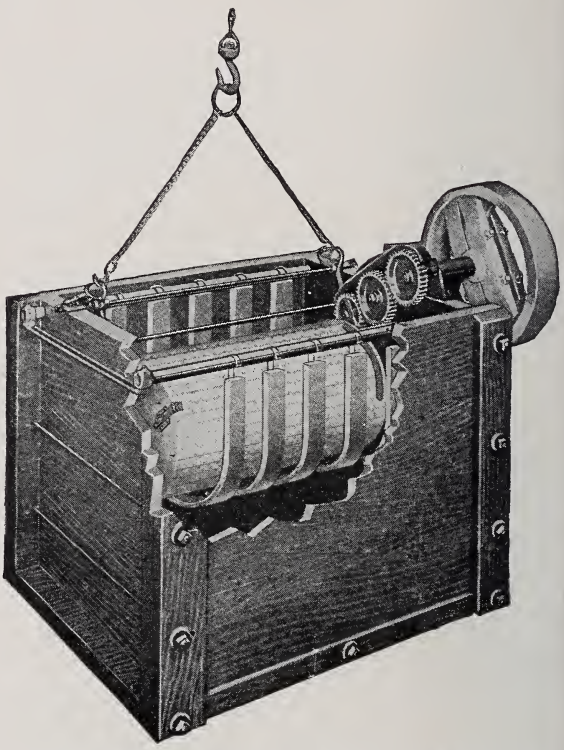

Fig. 60.—View of Rotating Plating Tank Showing Position of Anodes and Container During the Deposition Process

(General Platers' Supply Co.)

Another type of rotary plating tank is so designed that the articles are "tumbled" in a horizontal perforated cylinder revolving beneath the surface of the electrolyte. To load or unload the cylinder, it

is necessary to hoist it above the surface of the solution, when the cover plate can be removed. Better results can usually be obtained if curved anodes are used, thus providing an anode surface below the cylinder as well as at the sides. The cathode connection to the article is formed by a contact with metal pen-

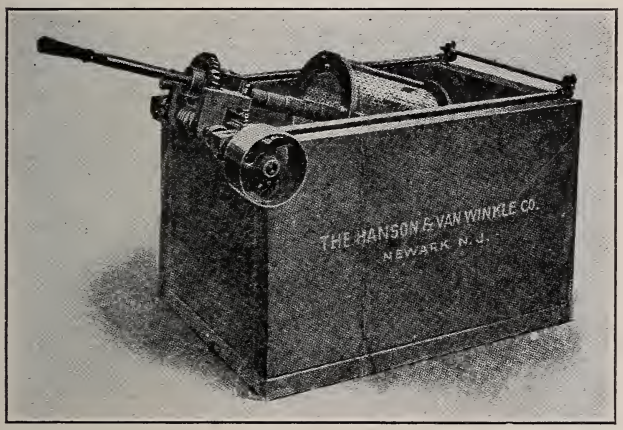

Fig. 61.—Oblique Plating Barrel. This Type Is Quite as Efficient as the Horizontal Machine and May Be Employed for Smaller Quantities of Work.

(Hanson & Van Winkle Co.)

dants suspended from the metal axis of the cylinder. This axis is, of course, connected to the negative bus bar. The cylinder is constructed of a non-metallic substance, such as bakelite, and is thus not affected by the plating currents. The barrel type machine is also designed as shown in Fig. 61.

In operating any of these barrel-type plating ma-

chines it must be remembered that they are quite similar to the still tank as far as the deposition process is concerned. The speed of rotation must be slow, fifteen to twenty r.p.m. being sufficient. No good and much harm will result if the barrel is operated at a higher speed.

AUTOMATIC PLATING MACHINERY

The trend of the industrial world is toward the use of automatic machinery. While electroplating requires, perhaps, more of the human element than most forms of industry, progressive manufacturers have placed upon the market machinery designed to increase production with a corresponding decrease in labor and time. Various types of plating machines are illustrated; a typical automatic installation is outlined in Fig. 62.

Perhaps the most simple type operates as a conveyer, the article passing through the solution in a definite time at a rate of speed determined by the length of time required to deposit the metal coating. So important is the use of the automatic-moving tank in modern electroplating, that a detailed description is necessary. Through the courtesy of the Crown Rheostat and Supply Company, it is possible to give the following excellent comparison between still and automatic-moving tank methods.

AUTOMATIC MOVING TANK

"In considering the electrical deposition of metal in the old style plating tank, it is found necessary to use a comparatively low ampere per square foot of cathode surface and a low voltage. This is due

to the fact that in the act of electroplating, hydrogen gas bubbles form on the cathode and if a higher current were used, the work would burn or become rough. This necessity for a low current therefore causes a much slower deposit to take place than could be obtained if the hydrogen bubbles could be eliminated in some way.

By the use of a moving apparatus to convey the articles through the tank as they are being plated,

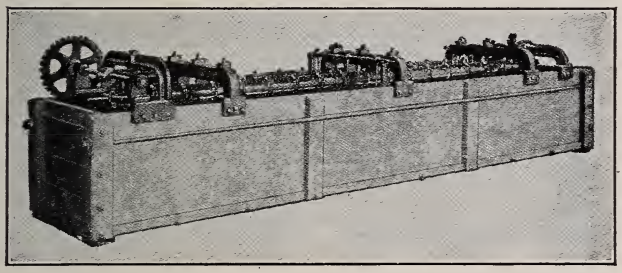

Fig. 62.—General View of Automatic Moving Plating Tank

this and many other defects can not only be removed, but new and favorable conditions created.

The act of moving the cathode through the solution, frees the hydrogen bubbles from the material and a higher current can therefore be used without burning the surface. The result is a much quicker and denser deposit.

Another condition encountered in still tank practice, is that it requires a good deal of judgment and care on the part of the plater, in order to leave all of the material in the tank the same length of time,

and to secure uniform work, even under favorable conditions.

After the proper length of time is determined for plating, it will require no careful watching or judgment as to how long each piece is left in the moving tank as the pieces must remain in the same length of time. They are placed on racks which are hung on the conveyor chain, and when they have made the circuit of the tank and come back to the starting-point, they are removed by the operator. This results in a deposit of uniform thickness on all the articles.

In the still tank, it is seldom found that all the conditions in the tank are perfect. Some of the anodes, for instance, will secure a better electrical contact owing to the condition of the surface of the anode hook or to dirty contacts on some of them, or to corrosion or dirt on the anode-contact bar. Other anodes become foul and must be frequently cleaned or they will wear away unevenly. Under these conditions, no matter how skillful the plater is, it is almost impossible to secure uniform, even work, because material placed near the active anodes will plate faster than that which is placed near sluggish or inactive anodes.

On the other hand, with the automatic-moving apparatus tank, the anodes cannot get foul owing to the agitation of the solution, and if some of them dissolve or wear away, more than others, due to poor contacts, it will not affect the uniformity of the work because each article will pass all of the anodes, both good and bad, and each piece will have the same exposure as all the other pieces.

Another point with the still tank which is seldom

realized, is the fact that the solution in immediate contact with the cathode (article being plated) becomes impoverished of metal after a very few minutes, and the molecules of metal having to be carried from an increasing distance as the plating progresses, the amount of deposit taking place is diminishing on

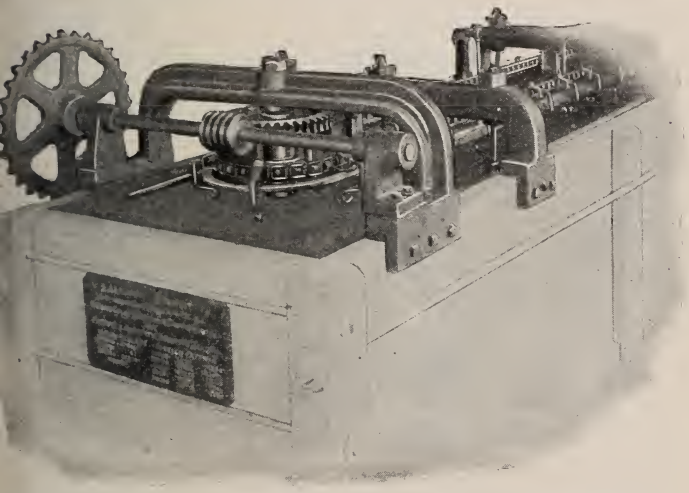

Fig. 63.—View of Automatic Plating Tank, Showing Driving Worm Gear and Copper Hooks

an increasing scale. On articles having recesses, this is particularly noticeable as the solution in the recesses soon becomes impoverished, and after that the molecules of metal are only deposited on the high spots or places nearest their line of travel.

With the moving apparatus tank, however, rich solution high in metal content, is always in contact

with the cathode, because as fast as the metal is taken from the solution, the articles are passing on to new solution. This condition aids materially in quickening the deposit, and its beneficial results are particularly noticeable in deep recesses which are impossible to plate or electrogalvanize in a still tank. The

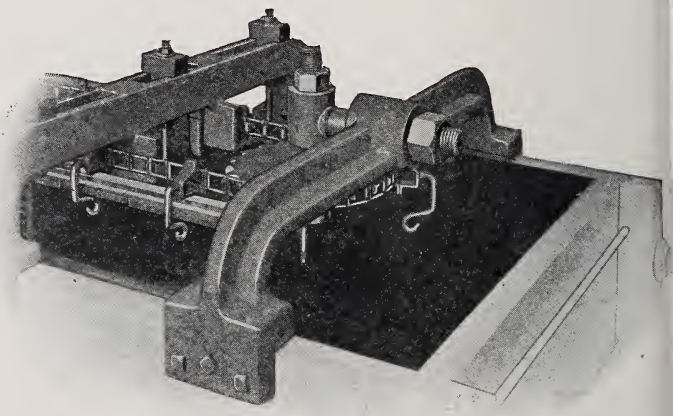

Fig. 64.—View of Automatic Plating Tank Showing Arrangement for Taking up Slack in Chain

action set up by the material passing through the tank is also sufficient to stir or agitate the fluid enough, for the dense solution is always found near the anodes, to become mixed with the poorer solution impoverished by the cathode and the latter solution to be moved toward the anode. This in turn aids and quickens the dissolving of the anodes.

The moving apparatus tank goes beyond the mere correcting of certain defects of the still tank and sets up new and attractive conditions. For instance, the racks above referred to are hung on copper hooks which are fastened to the link-belt conveyor chain. These hooks slide on a flat copper conductor bar, and this sliding operation is just enough to keep the connections bright and clean.

The automatic moving tank, for two reasons, requires less floor space than the still tank. In the first place, these tanks can be set close together. They are loaded from the end and do not require the wide passageway between them that still tanks do. In the second place, they plate the work quicker than still tanks and fewer of them are required. If your plating department is crowded and congested the automatic-moving tank will solve your problem.

PRINCIPAL ADVANTAGES

It can readily be seen then, that with a moving apparatus we can use a higher current, resulting in a quicker deposit; employ unskilled labor owing to fixed length of time of articles in the plating bath; secure uniform deposit on all work because of equal exposure to all anodes; quicken the deposit and plate in recesses because articles are always in contact with rich solution; save each of your platers from walking needlessly a long distance each day; prevent a big loss of current which you are now losing by being able to use only about one-half of the voltage generated; and aid the above-created efficiency by automatically keeping the cathode conductor bar clean and bright.

GENERAL DESIGN

The apparatus is so laid out that it can be installed on any tank which is 2 feet 6 inches wide. There are two main yokes and two or more conductor supporters which are bolted to the top of the tank. The moving apparatus, anode conductor bars, cathode conductors, etc., are supported by these yokes and supports. There is no part of the apparatus in the solution except the agitator.''

OTHER TYPES

Automatic machines are also in use for producing plated surfaces on hoop-iron, wire, strip copper and brass, and wire mesh. These machines are distinctly automatic in that they provide for pickling and clean-

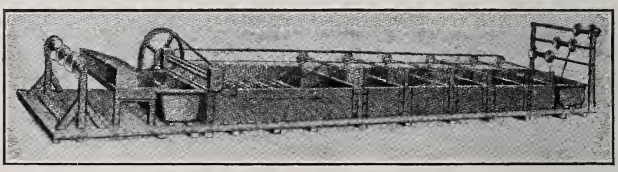

Fig. 65.—Machinery for Electroplating Wire, Hoop Iron, and Similar Work by the Continuous Process Method.

(Hanson & Van Winkle Co.)

ing operations prior to that of plating. Although the work is usually dried and wound on reels at the completion of the process, a lacquering operation may be added, when it is necessary to provide a drying oven. Machinery for electroplating metal wire and strips is shown in Fig. 65. The automatic plating apparatus for handling wire mesh is shown in Fig. 66.

A mechanical plating tank for chains, automobile wheel irms, etc., is shown in Fig. 67.

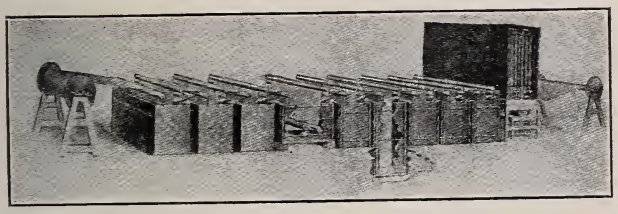

Fig. 66.—Special Automatic Machinery for the Electro-Deposition of Protective Metals on Wire Mesh. Note the Arrangement for the Preparatory Processes, Plating, Washing, Drying, and Lacquering.

(Hanson & Van Winkle Co.)

Other machines are on the market which are designed for special work, such as plating chains, bar-

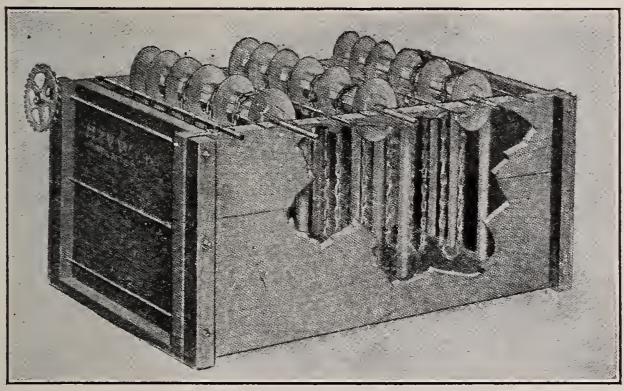

Fig. 67.—Mechanical Plating Tank for Chains, Automobile Tire Rims, and Work of a Similar Character.

(Hanson & Van Winkle Co.)

rel hoops, automobile tire rims, metal tubing and the like. Automatic plating machinery will undoubtedly be further developed to provide methods of handling many of the more tedious operations now requiring human effort.

TANKS FOR PREPARATORY PROCESSES

Equally important to the plating tank equipment are the several containers used for the preparatory processes. Tanks for pickling, acid dipping, potash solutions, hot water, and scouring are all necessary in the production of efficient work.

PICKLING TANKS

Foundry work, drop forging, drawn-steel work which has been annealed several times, and other heat-treated articles are usually delivered to the plating room with a surface coating of hard scale. While this scale may be removed by mechanical means, such as tumbling and sand blasting, a chemical process termed pickling, is often employed. The work to be cleaned is immersed in a weak acid solution until the scale or sand flakes off, or is dissolved. When it is not intended to pickle large quantities of work, or if the articles are small in size, a very suitable vat may be prepared from one-half of an oil or vinegar barrel. Usually, however, wooden tanks, such as described earlier in this chapter for plating work, are constructed especially for this chemical process. For cold pickling, an asphaltum lining is given to the tank. As is the case with most chemical solutions, action is quickened by heating. It is therefore advisable to heat the pickle bath by means of lead pipe

steam coils placed in the bottom of the tank. Sufficient coil capacity should be provided to raise the temperature of the bath to approximately 200° F. The acid tanks may be lead lined for hot pickling, but this is not essential. It is best, though, to line the interior of the tank with light boards to protect the steam coils or, in the case of cold pickle tanks, the asphaltum. Regardless of the care exercised, castings will drop or baskets will strike the sides of the tank, causing damage unless the board protection is provided.

BRIGHT DIPPING TANKS

As will be explained later, tarnish and other light foreign matter may be quickly removed from the surface of metals by dipping in undiluted acid. This

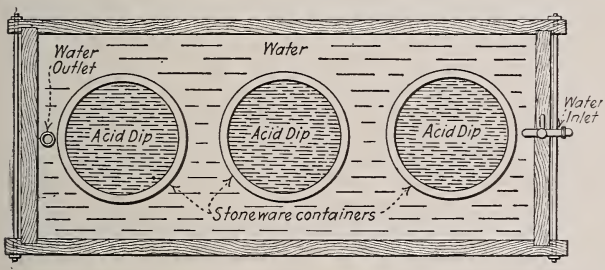

Fig. 68.—Bright Dipping Tank Showing Acid Containers and Water Bath

process is usually termed acid or bright dipping. Large tanks are seldom employed for this work on account of the cost of the acid. Stoneware containers, set under a hood and in a vat of warm water are provided. The plan view of such an arrangement

is shown in Fig. 68. One or more acid containers may be used, according to the shop requirements. The wooden rinsing vat is of construction identical to the plating and pickling tanks, with the exception of the water overflow. This device is merely a pipe passing through the bottom of the tank and with a height inside equal to the desired depth of water.

SPECIAL VENTILATING HOODS

During the bright dipping process, heavy poisonous fumes arise from the acid. A special ventilating

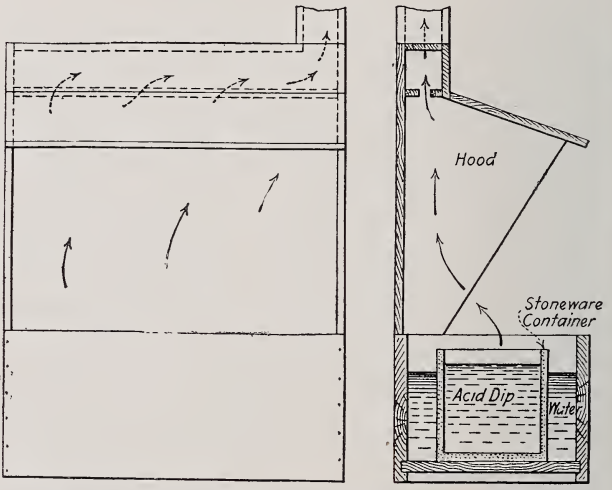

Fig. 69.—Acid Dipping Tank With Ventilating Hood

hood is a necessity, therefore, to keep the air in the plating room free from these vapors. Fig. 69 shows a hood designed to be placed over the dipping tank

just described. It is constructed entirely of wood, preserved with asphaltum paint. It must be remembered that the acid fumes from the dips are much more concentrated than those collected from the plating tanks. The exhaust pipe, therefore, should not be constructed of metal but of wood or of glazed tile pipe. Wood is employed throughout in the hood shown here. The dimensions are dependent upon the available space; the plater can easily follow the general design, assigning such dimensions as are required.

LYE AND POTASH TANKS

Perhaps the most suitable tanks for lye and potash dips are of steel. Since the solution must be maintained at nearly the boiling point, steam coils should be provided. Jacketed tanks or kettles are even more satisfactory. No hood is provided for such dips.

HOT WATER TANKS

An unlined-wooden tank serves quite well for hot water, although a more expensive steel or iron container may, of course, be used. The hot-water temperature is maintained by the use of steam coils. Jacketed steel kettles are also excellent for such purposes. It is best, for the convenience of the plater, that an overflow pipe as well as a faucet connected to the fresh-water supply, be a part of the tank equipment.

SCOURING TANKS

The scouring and rinsing tank is always in constant use; practically every article to be plated must receive some degree of scrubbing or scouring. It is

best, then, to place it centrally with respect to the plating tanks, and to so construct it that work can be done with little inconvenience. One suggestion is to raise the tank and scouring board to such a height that the plater can clean the work without stooping over. The tank is usually made of sound

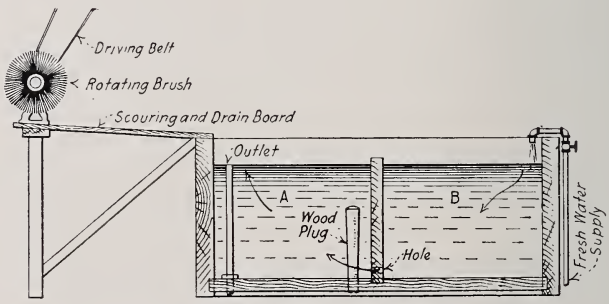

Fig. 70.—Scouring Board and Rinsing Tank

two-inch cypress boards and, with the exception of the lining, which is unnecessary in this instance, the construction is in general similar to the plating tank described in this chapter. The scrub board is located at one end of the tank and is so inclined that the surplus water drains back into the container. It is often advantageous to divide the tank by a wooden partition slightly higher than the excess water outlet, as shown in Fig. 70. A hole in the bottom section of the partition allows free flow of water from one side to the other. The work is first scoured on the board, then washed in the outlet compartment A, and finally rinsed in the fresh-water section B.

While most of the scouring is done with hand brushes, greater speed may be obtained if a small polishing head equipped with a rotating wire-scratch brush is mounted on the board. The increase in production will soon compensate for the additional fixture.

CHAPTER VI

MISCELLANEOUS PLATING ROOM EQUIPMENT

The Steam Generator—The Drying Oven—Hot Sawdust Box — Air Compressor — Time Dial — Plating Anodes — Flat Anodes — Corrugated Anodes — Elliptic Anodes —Curved Anodes — Slinging Wire — Plating Baskets — Plating Hooks—Plating Racks—Special Racks—Dipping Baskets—The Respirator—The Hydrometer—The Thermometer—Litmus Paper—Acid Pump—Carboy Inclinator—Speed Indicator—Clothing.

THE STEAM GENERATOR

The more important plating room equipment has already been described, but there are several miscel-

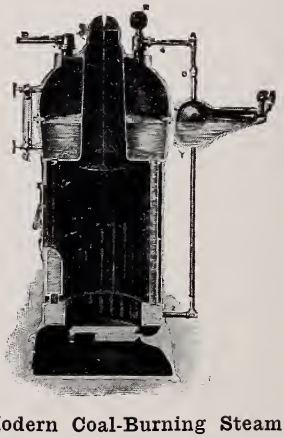

Fig. 71.—Modern Coal-Burning Steam Generator

(Crown Rheostat & Supply Co.)

laneous fixtures that should be considered before taking up the subject of the deposition process. Steam, for instance, plays an important part in plating-room operations. For the heating of electrolytes, pickles, lye dips, and water baths, as well as drying ovens and the hot sawdust box, steam is almost a necessity. Thus, where there is no source of steam supply, a low pressure boiler should be installed. The market affords a wide selection of such steam generators. A modern, automatic type, Fig. 71, uses coal as a fuel.

THE DRYING OVEN

Some types of work cannot be dried in sawdust and must therefore be hung in a drying oven until all traces of moisture have disappeared. Such ovens are

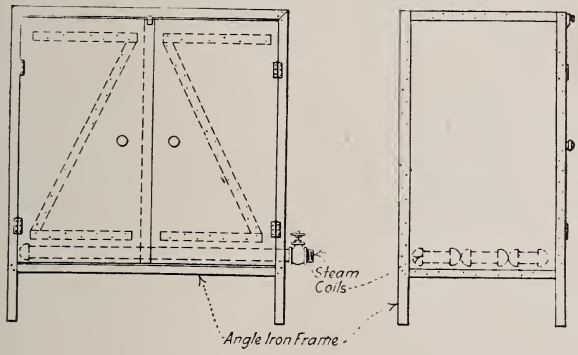

Fig. 72.—Steam Heated Drying Oven

manufactured, but since their construction is not difficult, it is suggested that the plater build one best suited to his particular requirements. The source

of heat may be either gas or steam, though the latter is preferable. Fig. 72 presents a general outline of a steam-heated drying oven. The framework is of light angle iron, the adjoining pieces being bolted together. The walls, bottom, and top are of galvanized sheet iron, riveted to the angle iron framework. The doors are of slightly heavier sheet iron and are reinforced on the inside with angle-iron braces. They are hinged to the frame supports, as shown. Steam coils are placed in the bottom to furnish the necessary heat. The interior may be equipped with shelves or hooks, depending upon the character of work to be placed therein.

HOT SAWDUST BOX

One of the most convenient methods of drying quantities of small bright dipped or plated articles is to surround them with hot sawdust. The pieces

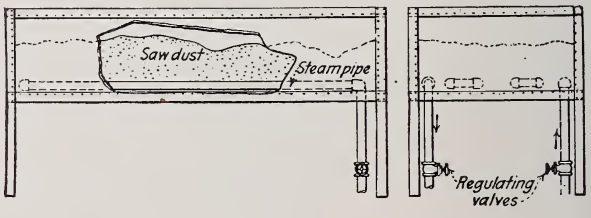

Fig. 73.—Side and End Views of Hot Sawdust Box, Showing Simple Construction

are placed in a riddle, the meshes of which are smaller than the articles, and the sawdust poured over them. Shaking the riddle allows the sawdust, which has

absorbed the moisture retained by the pieces, to fall through, leaving the work behind thoroughly dry. Box-wood sawdust is usually used for this operation because of its absorbent qualities.

As may be seen from Fig. 73, a hot sawdust box is easily constructed. Like the drying oven, the

Fig. 74.—Hot Sawdust Box as Manufactured

framework is of angle iron and the sides and bottom of galvanized sheet iron. Steam coils placed in the bottom supply the required heat. It must be admitted, however, that a manufactured box will be more substantially built and certainly more pleasing in appearance. There are several styles of these boxes on the market, the one shown in Fig. 74 being a good type.

AIR COMPRESSOR

As was stated in Chapter V, compressed air is used to advantage in the agitation of electrolytic solutions. The sand-blast machine, the lacquer spray, and sev-

eral other devices also require air under pressure. Factories usually operate a large compressor which furnishes air to the plating room as well as other departments. Individual shops will, in many instances, have to supply their own compressed air. Before purchasing a compressor, a summation of all work requiring such service should be made to insure the selection of a machine of the correct capacity. The most economical method of driving the compressor is by an individual motor, thus eliminating all line shaft losses when the machine is idle.

TIME DIAL

A convenient method of denoting the time at which work should be removed from the plating tank is

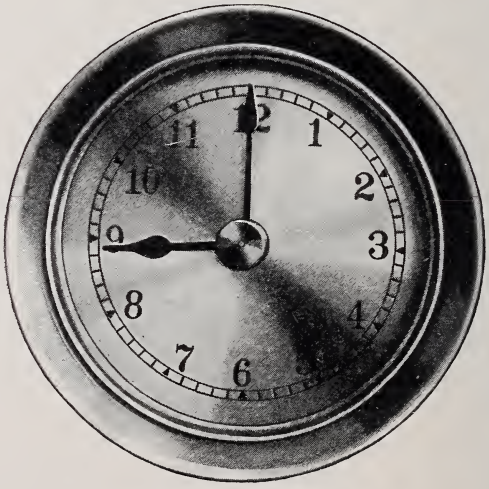

Fig. 75.—Time Dial

(Crown Rheostat & Supply Co.)

furnished through the use of a time dial, such as is shown in Fig. 75. A thumbpiece connects through the glass with the hands, allowing the latter to be set to indicate the hour and minute. If possible, a time dial should be placed above or on each active tank.

PLATING ANODES

There are several shapes and kinds of plating anodes on the market. Many of these are especially designed for certain classes of work. For this reason a brief discussion of the more important types is necessary.

FLAT ANODE

The flat anode was for many years the standard type used for all classes of work. While still popular, other shapes can now be adapted to greater advantage in many instances. For nickel plating cast anodes may be employed. A good point featured by several manufacturers is the use of either the separate or cast—in nickel hook. Other metals will, if allowed to stand in the nickel solution, act with a detrimental effect on the bath, preventing a clean, white electro-deposit. Furthermore, if the hook and the anode are of the same metal, the full surface may be immersed, thereby allowing an economy in material.

Copper and bronze anodes may also be plate castings. While brass anodes may be of rolled metal, castings are often preferred because of their solubility in the solution. Tin plates are also usually furnished in the cast form. Experience shows that the anode surface in the solution should be the equivalent of the area to be plated. On the other hand,

silver and gold anodes need not present a surface area identical with the work. Of course, only anodes of pure metal should be used if good work is expected.

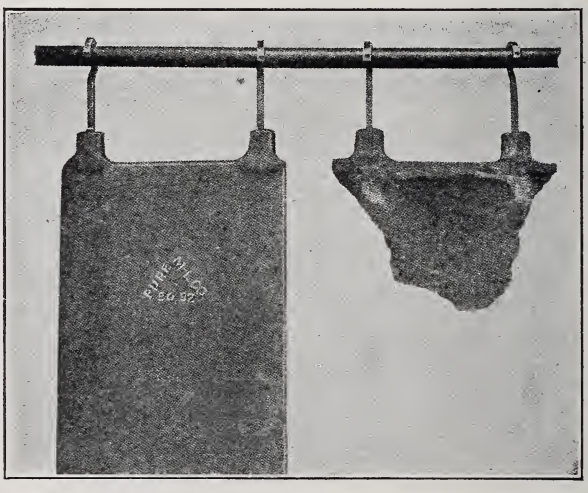

Fig. 76.—Characteristic Disintegration of Flat Anode. Note the Waste. The New Anode Weighed 22½ Pounds; the Stub Weighed 2 Pounds, 10 Ounces: Waste, 11.7 Per Cent. Compare this with the Two-Bar Type, Fig. 78

(A. P. Munning & Co.)

The characteristic disintegration of a flat anode is shown in Fig. 76 and shows amount to be considered as waste.

CORRUGATED ANODES

Quite similar to the flat-plate anode is that presenting a corrugated surface. The advantage of this

type is the large exposed surface in comparison to the flat anode of equal width. This is a valuable feature in nickel plating, for since this metal does

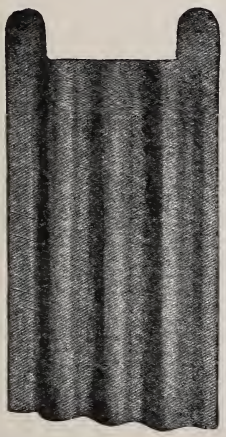

Fig. 77.—Corrugated Anode

not readily dissolve, the large exposed area aids in maintaining the metallic strength of the solution without the addition of nickel salts. A corrugated anode is shown in Fig. 77.

ELLIPTIC ANODES

Anodes whose cross sections are round or elliptical in shape are finding favor in the plating room. The elliptical anode is especially featured by the producers for its economy and perfect plating characteristics. When there is poor, or no agitation of the electrolyte, it is noticed that the edge of a flat anode disintegrates more quickly than the center portion,

and that the effect on the cathode is noticeable. The section of the cathode nearest the edges of the anode receives the heaviest deposit. The round or elliptic

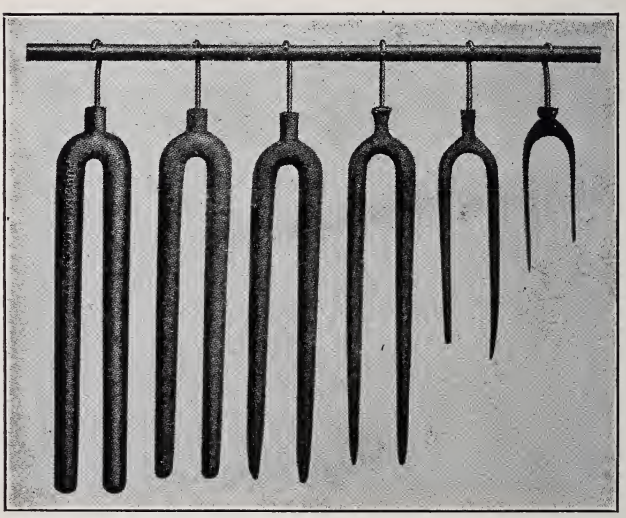

Fig. 78.—Characteristic Stages in the Disintegration of 2-Bar Anodes. Note the Uniform Wearing Qualities. The Nickel Anode on the Left Weighed 14 Pounds, that on the Right, in the Last Stage of Disintegration, Weighed 8½ Ounces. Waste 3.8 Per Cent

(A. P. Munning & Co.)

type of anode, however, allows an even disintegration with the resulting even deposit on the cathode. Thus, this type of anode can be left in the electrolyte until entirely consumed, this again showing a saving over the flat variety. Such a round section anode, in the two-bar form, is shown in Fig. 78.

CURVED ANODES

Special work or mechanical plating machinery may require anodes which are curved. For instance, revolving, horizontal plating barrels, such as described

Fig. 79.—Curved Anode, Circular Cross Section

in Chapter V, produce a more uniform deposit on their contents when a row of curved anodes is placed on either side, allowing an equidistant anode surface on the bottom as well as on the sides of the work.

Other forms of anodes are available and may, no doubt, be used with satisfactory results. In selecting an anode, regardless of shape, special attention must

Fig. 80.—Curved Anode, Rectangular Cross Section

be given to the actual active surface that will be available. It is the active or submerged surface that is valuable; all else is a useless and needless expense. The curved anodes in Figs. 79 and 80 are the types used with plating barrels.

SLINGING WIRE

The usual agent employed in suspending light-weight work in the electrolytic solutions is copper wire. Each article is securely fastened with a length of copper wire, the latter then being wrapped several times around the cathode rod to form an electrical

connection when the cluster is hung in the tank. Several times during the plating process the point of fastening of the wire to the article should be changed. The danger of an uneven deposit on the surface covered by the wire is then avoided.

PLATING BASKETS

Small articles may be plated in quantities in a wire tray or basket. The result obtained by this method

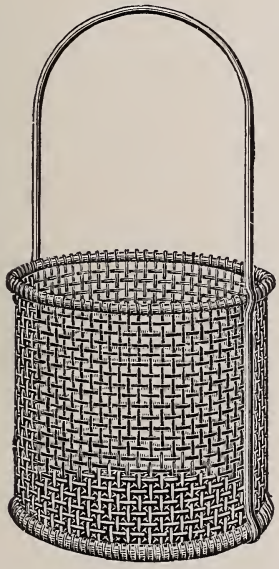

Fig. 81.—Cylindrical Shaped Wire Plating Backet

will not, of course, compare favorably with that secured on the individual wire slung pieces. But, because of the convenience and time saved, the basket

process is sometimes resorted to where the only purpose is protection from rust or tarnish, and not improvement of appearance. Even in this case, it is necessary to occasionally shake the basket, when it is suspended in the plating tank, so that the contents may so change their relative positions that a fairly even deposit is assured. A typical plating basket suited for a variety of work is depicted in Fig. 81.

PLATING HOOKS

Large or heavy articles are often suspended in the plating bath with copper hooks; one loop is attached to the work, while the other loop is placed over the

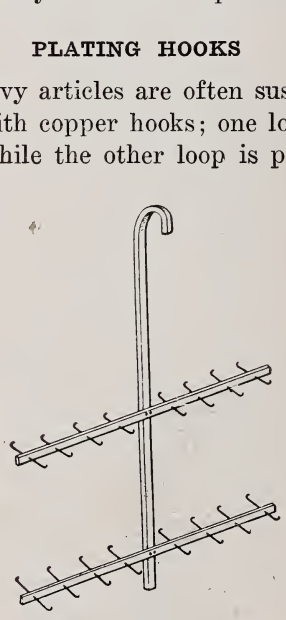

Fig. 82.—Plating Rack

cathode bar. The design of the hooks, as well as the gauge of the material used in their construction, depends upon the class of work handled. It is well to have an assortment of hooks on hand so that any

size of article may be placed in the tank on short notice, if necessary, without the delay of forming the proper hook for it.

PLATING RACKS

A plating rack affords the most convenient method of individually suspending quantities of small parts

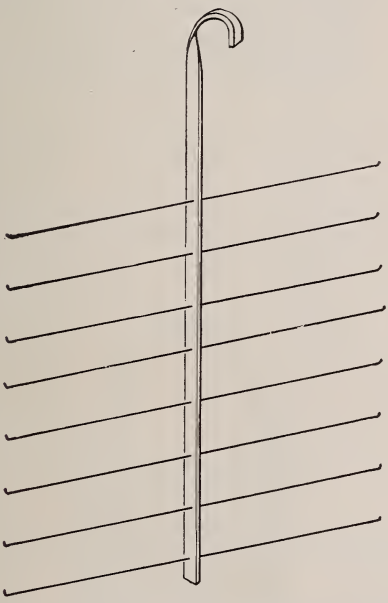

Fig. 83.—Rack for Plating Large Quantities of Small Parts, a Number of Which are Strung on Each Horizontal Wire

in a still tank. Such racks are not difficult to construct, and they eliminate the necessity of employing wire or a separate hook for each piece of work. In general, a rack consists of a copper rod to which cross-

pieces of the same material are riveted and soldered. The crosspieces are provided with hooks to hold the articles while the supporting rod has one end so formed that it may hang over the cathode rod. Often two supporting rods are furnished, thereby increasing

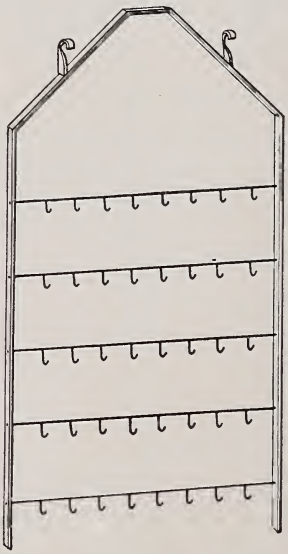

Fig. 84.—Double Support Plating Rack for Small Articles

the rigidity of the rack. Note the illustrations in Figs. 82 and 83, which show simple plating racks, and that in Fig. 84, which shows a special type having a double support.

SPECIAL RACKS

The electroplater is often called upon to finish castings of unusual shapes, drawn metal parts, or

pipes. If a deposit on the interior surface is expected, special racks providing a separate anode

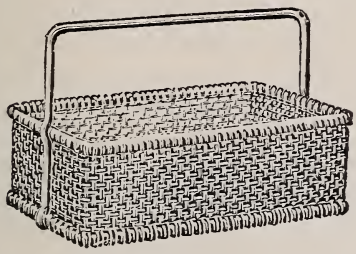

Fig. 85.—Rectangular Shaped Wire Dipping Basket

must be used. The plater must exercise his ingenuity in designing such racks, keeping always in mind that quickness in adjusting the work in the rack or removing it is as essential as is the securing of a good deposit. This is particularly important in the handling of large quantities of commercial work.

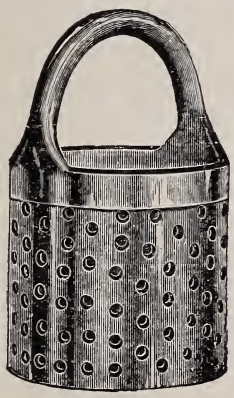

Fig. 86.—Stoneware Dipping Basket. Straight Type

DIPPING BASKETS

While wire hooks may be employed in acid-dipping work, greater convenience is found in the use of stoneware or wire dipping baskets. Stoneware baskets are heavy and subject to breakage, but they can be used without the danger of disintegration in acids

Fig. 87.—Respirator

(Mott Sand Blast Mfg. Co.)

or potash. Wire baskets, on the other hand, are light in weight as well as durable, but cannot be subjected to acids for any great length of time. Aluminum wire baskets or trays, for example, are affected to some extent by both potash and muriatic acid, but are nevertheless quite popular on account of their exceedingly light weight. Brass and steel wire baskets are also manufactured for dipping operations. A rectangular shaped wire dipping basket

is outlined in Fig. 85, and a straight type stoneware dipping basket is shown in Fig. 86.

THE RESPIRATOR

As a protection against inhaling poisonous fumes or injurious abrasive dust, a filter mask or respirator is often used. This device is worn strapped in such a position that it effectively covers the nose and mouth, allowing no air to enter except that which passes through a filter, such as a wet sponge. Exhaled air escapes through an automatic valve in the side. It is, of course, understood that if suitable ventilating equipment is provided for the plating and polishing rooms, there is little necessity for wearing a respirator. A respirator, as it looks when worn by the operator, is shown in Fig. 87.

THE HYDROMETER

A hydrometer is a device for measuring the specific gravity, the relative density, of solutions. In

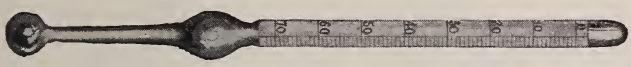

Fig. 88.—A Hydrometer For Testing the Density of Plating Solutions

(Crown Rheostat & Supply Co.)

appearance it is similar to a thermometer glass with the exception of the bulb which is filled with lead shot instead of liquid. The scale markings are, of course, laid off to a different standard. By allowing the hydrometer to float, bulb downward, in a test tube or other container of any solution, the density

of the latter is found by noting the scale reading at the solution surface level. An acid Baumé hydrometer with a scale of 0°–20° is adequate for most plating solutions, although a scale of 0°–70° is necessary for acid and acid dips. Undoubtedly the hydrometer is most valuable in testing nickel electrolytes. A registration at 6° to 8°, for instance, indicates a good solution, while any point showing below 6° warns that the bath is becoming weak in metal and requires the immediate addition of nickel salts. The simplicity of the hydrometer for testing the density of the plating solutions is shown in Fig. 88.

THE THERMOMETER

For determining the temperature of hot solutions, a thermometer having a scale reading up to 212° F., or higher, is often useful. Again, a thermometer is

Fig 89.—Glass Thermometer for Hot Solutions

(Crown Rheostat & Supply Co.)

of assistance to the plater in maintaining an even temperature in the drying oven or lacquer room. The glass thermometer, shown in Fig. 89, is for hot solutions.

LITMUS PAPER

Certain vegetable substances have the property of changing color when acted upon by acids or alkalies. One of these is litmus, which in acid solutions is red, and in alkaline, blue. The plater will find it to his advantage to provide himself with filter paper treated

with litmus, known commercially as litmus paper. If a drop of the solution, whose reaction is unknown, is placed on a sheet of blue litmus paper, that portion affected will turn light red, if the solution is even slightly acid.

ACID PUMP

Among the daily duties of an electroplater is the handling of concentrated acids. This is a dangerous task, particularly the emptying of heavy carboys,

Fig. 90.—Non-Corrosive Acid Lift for Carboys

(General Platers' Supply Co.)

unless some device is available to mechanically remove the acids from their containers. One of these devices is the acid pump. A rubber plug, through which a long and short tube passes, is substituted for the commercial stopper. By the use of a small hand-

pump connected to the short tube, the air pressure on the interior of the carboy is increased. The acid is

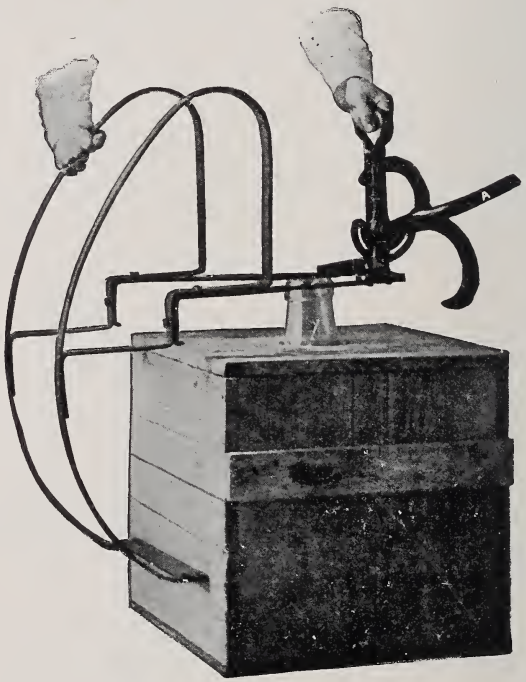

Fig. 91.—Carboy Inclinator

(General Platers' Supply Co.)

thus forced up the long tube and passes out into a pitcher or other container. Note Fig. 90.

CARBOY INCLINATORS

Another apparatus, which is, perhaps, more extensively used than the acid pump, is the carboy in-

clinator. There are many designs on the market, but the essential principle is the same for all; the carboy is rocked forward to the necessary angle on a portable adjustable frame, the acid pouring from the neck

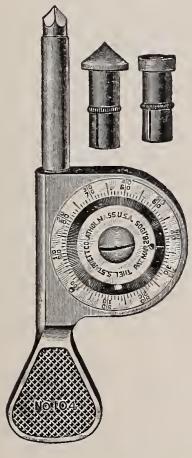

Fig. 92.—Speed Indicator

(L. S. Starrett Co.)

mouth into the provided container. Fig. 91 illustrates this device.

SPEED INDICATOR

The plating generator should always be driven at the speed specified on its name-plate. The only sure method of determining whether this speed is maintained is through the use of an indicator. There are many designs available, ranging from the simple revolution counter to the carefully adjusted electrical speed indicator. For plating and polishing room use

in determining the speed of motors, generators, shafting, buffing and polishing wheels, and the like, the most simple and inexpensive type of speed indicator will suffice. A very simple yet accurate instrument is shown in Fig. 92.

CLOTHING

While it is almost impossible to fully safeguard the clothing from acid burns, some protection is provided when rubber aprons, rubber gloves, and heavy shoes are worn. If the plating room floor is constructed as suggested in Chapter III, much relief from dampness will be enjoyed. Shoes with wooden soles may be obtained for use in rooms where water and acid are not drained from the floor.

CHAPTER VII

THE PREPARATION OF WORK FOR ELECTROPLATING

Cleansing—Removal of Burrs—Oblique Tumbler—Horizontal Tumbler—Charging the Tumbler—Sand Blasting—Two-Hose Sand Blast—Single-Hose Sand Blast—Sand Blast Room—Automatic Sand Blast—Sand Blast Rolling Barrel—Rotating Table Sand Blast—Compressed Air Supply—Sand Blast Sand—Cleansing by Pickling—Rinsing—Electrolytic Cleaning—Copper Striking—Polishing—Hot Lye Dipping—Scratch Brushing—Scouring—Removing Oxides—Stripping—Non-Metallic Work—Bright Dipping.

CLEANSING

The preparation of an article for electroplating requires more hard work than skill, yet the succeeding plating operations cannot be successful if the first cleansing process is slighted. Grease, scale, or rust on the surface of an article acts as an insulator against the passage of electricity and causes, at the best, a faulty deposit of metal. Under no circumstances should even the fingers touch the prepared work in placing it in the tank.

An electro-deposit will not efface scratches or flaws in the metal; the original surface must be smooth if the plated finish is to show no imperfections. All metals cannot be treated exactly alike, as experience shows, yet the essential operations are somewhat similar.

REMOVAL OF BURRS

Rough castings or other articles must, of course, be ground on an emery wheel to remove the heavy burrs. If the burrs are quite small and sharp, the castings may be shaken in a tumbling barrel. This operation not only removes the burrs but quite often the scale, sand, and rust. Obviously, no work having sharp corners that are to be preserved should be put in the barrel. One important advantage of tumbling is the amount of time and labor saved. After the work is placed in the barrel, no further attention need be given to it until the articles are completely burred and cleaned.

OBLIQUE TUMBLER

Small articles, not of a fragile nature, may be perfectly cleaned in an oblique tilting tumbler, such as that shown in Fig. 93. Metal barrels of sheet steel, cast iron, or brass are usually preferred to the less durable wooden type. As may be noted, the barrel can be tilted while revolving—backward when tumbling work and forward to eject it. The objects being tumbled may be inspected at any time without stopping the machine.

HORIZONTAL TUMBLER

The horizontal tumbling barrel is designed for larger work than that handled by the tilting type. Often there are two compartments, each furnished with a door which is bolted firmly in place. There are several types of horizontal tumblers on the market but all operate on the same basic principle.

Fig. 93.--Oblique Tilting Tumbler

(The Baird Machine Co.)

Tumbling barrels are, of course, power-driven, control being secured through the use of tight and

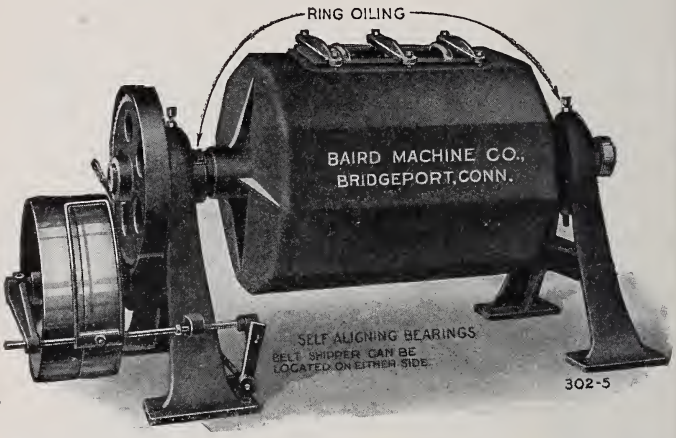

Fig. 94.—Horizontal Grinding Barrel for Tumbling Heavy Pieces

(The Baird Machine Co.)

loose pulleys. The horizontal tumbling barrel shown in Fig. 94 is well adapted for handling heavy pieces.

CHARGING THE TUMBLER

Sawdust is perhaps the cheapest absorbent agent available for the tumbling process. The barrel, regardless of type, is generally charged with an equal quantity each of work and sawdust. Under no circumstances should the drum be run more than two-thirds full. The sawdust absorbs the grease and moisture, while the rubbing action of the pieces removes the dirt, rust, and sharp edges.

In some cases it may be necessary to employ

abrasives such as gravel, broken glass, metal chips, sand, or pumice. The choice of the abrasive must, of course, depend upon the softness of the metal articles to be tumbled. Steel ball burnishing, which is another form of tumbling, will be described later.

SAND BLASTING

Light, fragile articles, which might be broken if tumbled, may be quickly cleaned by sand blasting. While tumbling or pickling processes require a certain amount of time, sand blasting produces a surface free from all grease or scale in a few minutes, regardless of the size or shape of the article.

Sand blasting, as the term implies, is the cleaning of any object with a stream of sharp sand driven from a nozzle by air pressure. The sand, striking the surface of the object with great force, produces a cutting action which effectively removes all foreign matter.

TWO-HOSE SAND BLAST

Perhaps the most simple type of sand blasting device consists of a Y-shaped nozzle, an air hose and valve, a sand hose, and the necessary helmet for the operator. The nozzle tip, which is the bottom part of the Y, is hardened to reduce excessive wear and may be quickly removed and replaced. One of the upper branches of the Y is connected through a hose to an air supply of 50 to 60 pounds. The nozzle air pressure is regulated through a conveniently placed valve. The opposite branch of the Y is connected through a rubber hose to a sand container, such as a box or pail. When

the air is allowed to flow, a stream of sand is drawn into it, the mixture passing from the nozzle as a sand blast. While the reference is made to the letter Y for descriptive purposes, manufactured nozzles are, of course, constructed more compactly.

SINGLE-HOSE SAND BLAST

Two-hose sand blast nozzles are cumbersome and difficult to handle. Accordingly, a single-hose apparatus is available where the sand and air are mixed in a compartment before entering the single

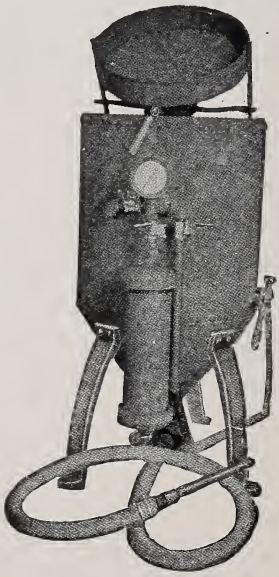

Fig. 95.—Single-Hose Direct-Pressure Sand Blast Machine.
(Mott Sand Blast Mfg. Co.)

1 inch hose provided for the operator. This hose is specially constructed to resist the wear of the sand and for most work a ¼ inch single nozzle with a hard tip is provided. A single hose direct pressure sand blast machine is shown in Fig. 95.

SAND BLAST ROOM

The use of the sand blast apparatus just described requires a special work room. If possible, the location should be such that the fine sand particles, which escape from the room in spite of precautions, do not settle on machinery, plating solutions, or recently lacquered articles. The bench, on which the work to be cleaned is placed, may be made of iron bars, thus allowing the escaped sand to pass through and into a container beneath. The walls on each side of the bench where the sand particles are apt to strike, should be protected with sheets of iron. Directly above the bench a hood should be placed, connected to a ventilating blower.

It is quite difficult to obtain men who will operate the foregoing apparatus. The sand blast clothing equipment is uncomfortable, especially during hot weather when the confinement in a closed room, with hot, heavy gloves on the hands, and stuffy helmet over the head, imposes severe hardship on the workman. The present-day tendency is toward the use of self-contained dust proof, automatic sand blasting machines.

AUTOMATIC SAND BLAST

One type of such a machine is shown in Fig. 96. It has a sand blast compartment of heavy sheet iron

in which are glass windows to enable the operator to view the work. Large articles undergoing sand blasting are placed in or removed from the compartment through a side-door. Small articles may be thrust

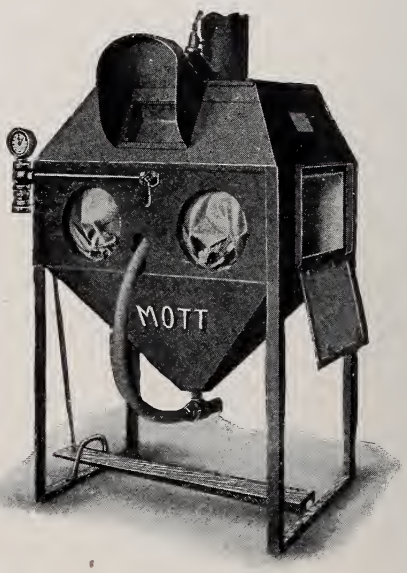

Fig. 96.—Sand Blast Cabinet
(Mott Sand Blast Mfg. Co.)

through the front hand holes. It is seen that these openings have cloth protectors to prevent injury to the workman's arms while the blast is in operation. Upon pressing the foot lever, the air valve is opened, allowing a blast of sand to be expelled against the work, which is held in the necessary positions until

a clean, matt finish on all surfaces is assured. The used sand drops back into the lower container where it is again drawn upward through the sand pipe on another cycle of work. Often a wire mesh is provided at the top of the sand container to catch any articles accidentally dropped from the hands.

SAND BLAST ROLLING BARREL

Another device manufactured for automatically sand blasting small work is the rolling barrel. This

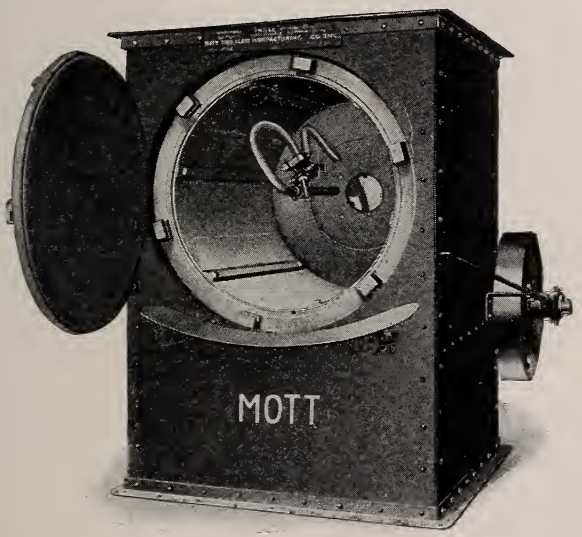

Fig. 97.—Sand Blast Tumbling Barrel

(Mott Sand Blast Mfg. Co.)

apparatus, when filled with castings, forgings, or other metallic articles, effectively cleans all surfaces without the supervision of an operator.

The machine is not unlike a horizontal tumbling barrel in appearance and action, but with the addition of the sand blasting features. An end opening is provided in the barrel in place of the usual side-door found on tumblers. Inside of the main barrel is a cylinder, several inches smaller in diameter, and constructed of perforated steel. Fixed in a position near the top of the inner cylinder are the sand blast nozzles. Work is placed in the steel cylinder, the end cover put in position, and the machine started. While it revolves at approximattely 2 r.p.m., thereby slowly rolling the articles in the barrel, the blast reaches every section of their surfaces, removing foreign matter. The used sand falls through the perforations in the cylinder to the space between it and the barrel. Buckets similar to those used on the old type water wheels, attached to the revolving barrel, carry the sand around the circle until it is emptied into the sand container above the nozzle. A typical sand blast rolling barrel is shown in Fig. 97.

ROTATING TABLE SAND BLAST

A third type of sand blast machine is shown in Fig. 98. As is indicated, the table revolves, carrying work placed upon it beneath a sand blast. The work passes through split curtains, these latter preventing the escape of abrasive material to the outside of the blasting chamber. The natural advantage of this machine over other types is that the operation is continuous, the work being loaded onto and removed from the exposed half of the moving table.

COMPRESSED AIR SUPPLY

If compressed air is available, as is the case if the sand blast machine is located in a large factory, special blowers are not required. Otherwise a com-

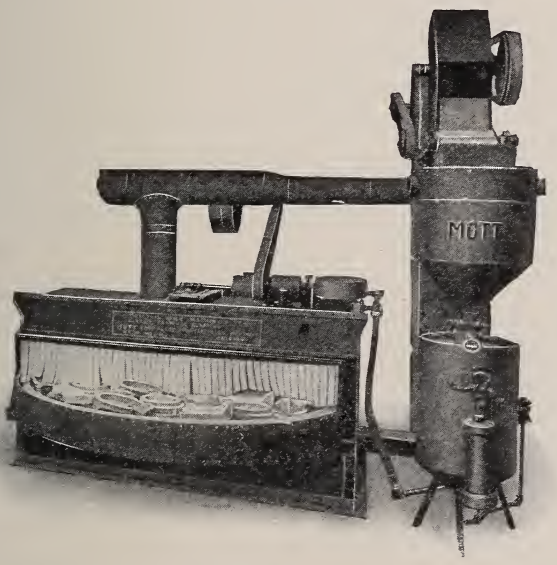

Fig. 98.—Rotating Table Machine Direct-Pressure Blast
(Mott Sand Blast Mfg. Co.)

pressed air plant must be installed. It is suggested that a reserve air tank be added, this to be charged when needed, and the supply of compressed air thus always available can be used to advantage for agitating plating solutions, or for drying work taken from the final hot water dip. It is best to locate the compressor in a dry place, free from dust. Wet air re-

duces the efficiency, and perhaps may stop entirely the operation of the sand blast machine.

SAND BLAST SAND

Some words of caution in the selection of the sand may be advisable. Not all grades of sand can be used with success. Usually a hard, clean silica sand is the best. The grains should be uniform in size and in texture though sharp sand is not necessary, as the edges soon wear off. Above all, the sand must be perfectly dry when placed in the blasting machine, even if it is necessary to heat it in order to remove all the moisture.

CLEANSING BY PICKLING

But tumbling, sand blasting, and other mechanical cleaning machinery is not always available for the removal of foreign substances from the surface of articles to be plated. In many instances, therefore, it is necessary to prepare the work by pickling. This process is one where the scale or other undesirable substance is removed from the metal surface by the chemical action of an acid. Sulphuric, hydrochloric or muriatic, and hydrofluoric acids, diluted with water, are the ones used to the greatest extent. Compounds are also manufactured which can be dissolved in water, and employed with the same success as acids. Pickle baths for iron articles are made by adding one part of sulphuric or muriatic acid to fifteen or twenty parts of water. The acid should always be added to the water; never the water to the acid. Brass work requires a slightly weaker solution of sulphuric acid

to obtain the best results. Hydrofluoric acid may be used in a very diluted form, if necessary. Its function is to dissolve the sand adhering to the castings yet without injury to the iron. A quick pickle for iron castings, which may be used cold or hot with good results, is composed of 20 parts water, 2 parts muriatic acid and 3 parts hydrofluoric acid.

The work is strung on wires and suspended or placed in the pickle. Care must be exercised to prevent over-pickling, which causes seams and roughness on the surface of the work. Warm pickle baths, of course, act with greater rapidity, but the acid fumes arising from the tanks are more dense.

RINSING

Immediately after removal from the pickle, the work is rinsed in cold water to remove all traces of the acid, and then dipped for a few moments in hot water. The purpose of the hot water treatment is to give the articles sufficient heat to dry quickly without forming rust.

ELECTROLYTIC CLEANING

Before passing on to a description of the final cleaning operations, some mention should be made of the electrolytic cleansing process. This method is rapidly gaining favor since it removes the foreign substances in much less time than the pickling bath, and lessens the labor of scouring.

Usually steel tanks are employed since they can then be conveniently used for the anodes, being connected to the positive terminal of the generator circuit. The electrolyte is an alkaline solution, such as

caustic soda, kept near the boiling-point by means of steam coils. The work to be cleaned is treated as a cathode and is, therefore, connected to the negative bus bar. An e.m.f. of 6 volts is sufficient, providing

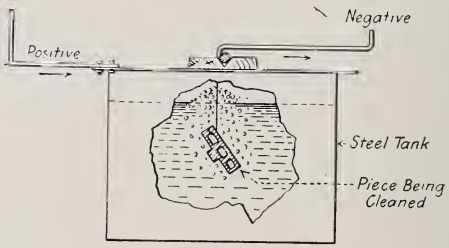

Fig. 99.—Electrolytic Cleaning. A Similar Process is Employed in Copper Striking

the current density is not less than 12 amperes per square foot. As might be expected, an increase in current density quickens the cleaning action. Large quantities of hydrogen gas are thrown off from the surface of the work, removing all traces of oxide and grease. Only a few minutes are required for this process, which is shown in diagram form in Fig. 99.

COPPER STRIKING

Copper "striking," or "flashing," is another favorite method of cleaning metal work. One advantage of this process is that a thin film of copper is deposited on the article, a perfect coating denoting a chemically clean surface. Upon this coating another metal may be deposited with excellent results. As in the process described in the paragraph on electrolytic cleaning, a steel tank, being positive, serves as the anode. The

article to be cleaned is connected to the negative terminal. An alkaline copper bath is used. Such an electrolyte may be prepared to suit the requirements of the work from a mixture of water, copper cyanide, sodium cyanide, and caustic soda. A copper deposit, under such conditions, forms in a few moments.

POLISHING

Should the work now present a rough surface where a fine smooth one is desired, a polishing operation is added. When the polisher has secured the desired grade of finish, the work is passed on to the plating room for the final cleaning operations, preparatory to entering the electrolyte. A discussion on polishing and grinding is given in Chapter IX.

HOT LYE DIPPING

For steel and iron pieces, the next step is an immersion, for 15 to 30 minutes, in a hot lye or caustic soda solution. While the strength of this solution may be varied to suit the character of the work, one part of lye to 40 parts of water by weight, proves sufficient for the average requirements.

For quick and positive results it is essential that the lye bath be maintained at nearly a boiling temperature. This is accomplished by the use of steam coils, as is indicated in Chapter V. After removal from this tank, the work is thoroughly rinsed in cold water and taken to the scouring bench.

SCRATCH BRUSHING

Scratch brushing and scouring produce in general the same effect, the former being slightly more severe.

The scratch brush is constructed of fine metal wires and is driven by mechanical power. Obviously, to secure desired cleansing results, the scratch brush

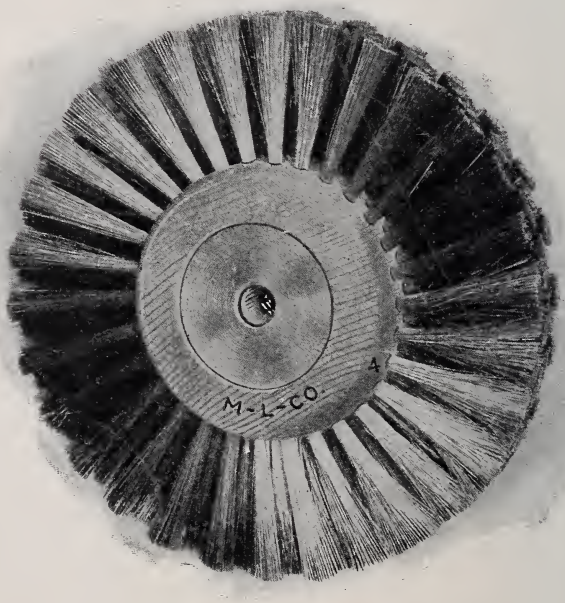

Fig. 100.—Circular Steel Wire Scratch Brush
(A. P. Munning & Co.)

wires are composed of a material harder than the surface being worked on, these being held by a wooden center hub, as shown at Figs. 100 and 101.

SCOURING

For scrubbing or scouring, fine pumice and water is often used. Although a hand brush can be employed

for most work, greater production in less time is obtained through the use of a power-driven rotary brush. This brush may be mounted with its lathe on

Fig. 101.—Small Circular Black Bristle Brush

(A. P. Munning & Co.)

the scouring board as suggested in Chapter V. The work of scouring is continued until the entire surface to be treated is as bright, clean and smooth as it is desired that the finished plated surface should be.

REMOVING OXIDES

When the articles are as clean as scouring can make them, they should be rinsed thoroughly in cold water and given a quick dip in muriatic acid. Upon rinsing them again in cold water, an inspection should be made prior to hanging them in the plating tank. Since moisture does not readily adhere to an oily surface, the appearance of dry spots on the work after rinsing indicates improper cleaning. Obviously,

in such instances, the cleaning operation should be repeated to remove the grease. Work that is held out of the solution will oxidize quite rapidly. This final acid dip, preparatory to the plating operation, is,

Fig. 102.—Cotton Potash Brush

(Crown Rheostat & Supply Co.)

therefore, a precautionary measure to remove all possible existing oxide. No time should thus be lost in placing the work in the electrolytic solution after it has passed through the last rinsing water.

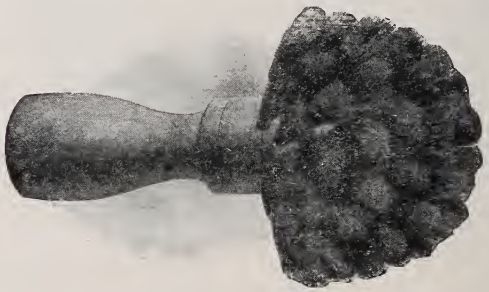

Fig. 103.—Goblet Shaped Brush

(General Platers' Supply Co.)

The same general operations may be followed for cleaning brass and copper objects with the exception of the final acid dip. To remove the oxide accumulation, a potassium cyanide dip is substituted for the

muriatic acid. After rinsing in cold water, the work is immediately placed in the plating tank. It might be worth mentioning that finely polished brass and copper articles rarely require scouring, but this is, of course, a question to be decided by the plater. A variety of scouring and cleaning brushes, for different classes of work, are shown in Figs. 102, 103 and 104.

STRIPPING

It is not unusual in the production of commercial work to discover, after plating is completed, that some mechanical operation has been omitted or that, through accident, perhaps, the original finish is dam-

Fig. 104.—Brush for Cleaning the Interior Surfaces of Vessels

(General Platers' Supply Co.)

aged. Before replating can be properly accomplished, the old deposit must be removed. Especially is this true of nickel or silver work. Two methods are available: the old deposit may be removed by acid dipping, or else stripped electrically by reversing the current direction, thereby using the articles as an anode.

Copper or brass plating is most easily removed by dipping the work in a hot solution of sulphuric and nitric acids mixed in a proportion of approximately six to one by volume. Rinse in hot water after dipping.

A good stripping solution for nickel finishes is composed of one part each, by volume, of water, sulphuric acid, and saltpeter (sodium nitrate). Nitric acid may be substituted for the saltpeter, but in proportion one-fourth that of the sulphuric acid. During the stripping process, continue to move the work back and forth through the solution. Rinse in hot water immediately after removal from the dip.

Silver may also be removed from copper alloy articles through the use of an acid dip. A hot solution of two parts sulphuric acid to one part saltpeter gives good results.

Silver may be stripped from iron and steel articles by utilizing a reverse current of about two volts, the articles forming the anodes, and one of the regular silver anodes forming the cathode. A stripping solution for this process is:

Water .....1 gal.
Potassium cyanide .....8 oz.
Silver chloride .....½ oz.

NON-METALLIC WORK

Articles which are non-conductors of electricity may be so treated that a metallic deposit can be formed on their surfaces. The purpose of such work may be commercial, artistic, or sentimental in nature. Metal-coated wood and leather work, porcelain or pottery has commercial value. Metalized flowers,

insects, leaves and the like, can be fashioned into novelties or jewelry. Keepsakes, such as baby shoes, can also be preserved if covered with a thin coating of copper or silver.

Large, stable articles, after being thoroughly washed with alcohol, are dipped or painted with shellac; fragile pieces are sprayed with the same varnish thinned with alcohol. After drying, a second coating of commercial electrotypers' varnish is applied. When this application has dried so that the article may be handled, dust on finely ground graphite or plumbago, smoothing it over the surface with a soft hair brush. Take care to brush the graphite evenly over every section to be plated, remembering that the metal deposits only where the surface has been prepared to carry electricity. Copper is undoubtedly the best metal to use for quick deposition and the prepared article should accordingly be hung in an acid copper solution. The deposit does not form at once on all sections of the surface but gradually works out from one or two points. When the desired thickness of copper is deposited, the work may be re-cleaned and transferred to another tank for the final deposit of the desired metal.

There are many other methods of preparing non-metallic surfaces for plating work. In general, however, the brief directions just given are sufficient for the average work. For further discussion of the subject the reader is referred to works on electrotyping.

BRIGHT DIPPING

The foregoing discussion has considered the various methods of preparing work for the electroplating

bath. But not all metals require plating, particularly brass and other copper alloys. They require only a refurbishing. It is, therefore, important to understand the art of removing from such work the oil remaining from machining operations, or the tarnish resulting from exposure. After the correct finish is received, through the action of acid dips, if a lacquer coating is added the original bright finish is preserved for some time.

One of the quickest methods of removing tarnish, or discoloration from metals, particularly copper alloys, is to immerse the stained piece in a strong acid solution. This process is known as bright dipping. There is little difference between the cleaning action of dips and pickles; the first is a rapid treatment while the latter is a prolonged operation. The instantaneous acid action is used with greatest success when the surface to be cleaned is smooth.

In general, the fastest acting dips are composed of nitric acid or sulphuric acid, alone or combined in varying proportions. For copper alloy articles, a dip of two parts sulphuric acid, one part nitric acid, and a sparse handful of common table salt for each five gallons of solution, gives a bright clean surface. For pieces that have been plated, and from which light discolorations must be removed before lacquering, a small quantity of water should be added to the solution. A soft, satin finish will be the result of using a dip of equal parts sulphuric and nitric acid in which has been dissolved one pound of metallic zinc for each five gallons of solution. For steel and iron, a favorite dip is prepared from equal parts of water and hydrochloric acid.

Acid dips should be prepared and used in stoneware jars placed in a tank of hot water. A dipping tank equipped with an exhaust hood is necessary since the acid fumes are quite poisonous. The construction of such a tank was described in a previous chapter.

When water is used, or two or more acids are mixed together, it is safest to combine them in relation to their weights, the heavier added to the lighter. Thus, if the mixture desired is composed of water and hydrochloric acid, the latter should be added to the former. Or if the solution is to be sulphuric and nitric acid, sulphuric acid, being the heavier, should be poured into the nitric acid. When zinc is employed to dull the finish, it should be dissolved first in the nitric acid, when it may then be added to the solution. Under no circumstances should acids be poured or mixed rapidly; such hasty action is dangerous.

Small pieces to be bright dipped are strung on wires, or placed in stoneware or wire baskets, while the larger work is handled separately on wire hooks. After a short immersion in boiling lye, the work is passed through hot water, then immersed in the acid dip for a few seconds. Upon removal, a thorough rinsing in hot water is given. Hot sawdust, blowing by compressed air, or oven drying must be used to prevent tarnishing.

CHAPTER VIII

PLATING SOLUTIONS AND THE ELECTRO-DEPOSITION OF METALS

Brass — Brass Plating Solution — Brass Anodes — Voltage Regulation for Brass Plating—Brass Coloring—Bronze—Bronze Plating Solution—Brass Anodes—Voltage Regulation for Bronze Plating — Copper — Copper Plating Solutions for Still Tank — Catalytic Agents — Copper Anodes—Voltage Regulation for Copper Plating—Copper Deposition—Copper Striking—Copper Coloring—Gold—Gold Plating Solution—Gold Anodes—Voltage Regulations for Gold Plating—Gold Deposition—Stop-Off Varnish—Iron—Iron Plating Solution—Iron Anodes—Voltage Regulation for Iron Plating—Lead—Lead Plating Solution—Lead Anodes—Voltage Regulation for Lead Plating—Nickel—Solutions for Still Tank Nickel Plating—Solution for Barrel Nickel Plating—Black Nickeling — Nickel Anodes — Voltage Regulation for Nickel Plating — Preparation of Work for Nickel Plating — Nickel Deposition—Silver—Silver Plating Solution—Silver Anodes—Voltage Regulation for Silver Plating—Silver Deposition—Silver Coloring—Tin—Tin Plating Solution — Tin Anodes — Voltage Regulation for Tin Plating — Tin Deposition — Zinc — Electro-Galvanizing—Solutions for Still Tank Zinc Plating—Solution for Barrel Zinc Plating—Zinc Anodes—Voltage Regulation for Zinc Plating — Zinc Deposition — Mechanical Machinery for Electro-Galvanizing.

It is difficult to determine the order in which the various metals used in electro-deposition should be

considered. Nickel and brass plating are of most interest, perhaps, to those handling hardware and similar articles. Again, zinc deposition appeals to the operator in charge of the plating division of a factory whose output must be coated with a cheap protective metal to afford freedom from rust rather than to add to its appearance. On the other hand, gold and silver deposition, especially the latter, is of great importance to the manufacturer of jewelry, cutlery, tableware, and similar goods requiring a beautiful polished surface. For convenience, then, rather than for their degree of importance, the several metals will be considered in alphabetical order.

BRASS

Commercially, brass is one of the important metals; it is undoubtedly the most extensively used of all alloys. Its color, yellow, varies in shade according to the percentage of zinc and copper in its composition; an increase in zinc with a corresponding decrease in copper produces a lighter color, and vice versa. In practice, the proportion of each metal content approximates: copper, 60 per cent, zinc 40 per cent. Brass presents a more pleasing appearance than zinc, but is higher in cost. On the other hand, it is less expensive than copper and is not quite so susceptible to tarnish. It is, therefore, an excellent protective metal for deposit on iron products, to preserve the latter from the action of the atmosphere.

BRASS PLATING SOLUTION

A solution prepared from the following formula gives excellent results in brass plating:

Water	1 gal.
Sodium cyanide	9 oz.
Copper cyanide	5 oz.
Zinc cyanide	2 oz.
Sodium carbonate	4 oz.
Ammonium chloride	⅓ oz.

The addition of a very small amount of arsenic trioxide (white arsenic), dissolved in caustic soda, improves the appearance of the deposit. Ammonia also appears to assist in creating a fine grained deposit and may be added to the solution if desired.

The sodium cyanide is dissolved in the water and the resulting solution poured into two containers, half in each. In one container the copper cyanide is dissolved; to the other the zinc cyanide is added. The first solution is then put into the plating tank and the other poured in slowly. Before adding all of the zinc cyanide solution, a test should be made to determine the color of the deposit. If the plated article appears too dark in color, more zinc cyanide solution is added until the desired color is obtained. The remaining ingredients are then placed in the electrolyte in agreement with the formula.

A cyanide electrolyte for brass plating yields the best results. Experience shows that for this copper alloy, acid solutions are impractical. The cyanide bath may be used for either still tank or barrel plating.

BRASS ANODES

As stated in Chapter VI, the anodes may be either in the form of castings or rolled plates. While the casting type is more soluble, many platers prefer the

rolled anode. Often copper and zinc anodes are used in alternate positions.

VOLTAGE REGULATION

For still tank brass plating the voltage may vary from four to six. For barrel work a slightly higher pressure may be required to produce the desired deposition.

BRASS COLORING

While a copper surface gives the greatest opportunity for successful coloring, many beautiful effects may be secured on brass-plated or solid brass articles. There are several available coloring solutions, among which are the following:

FOR BLACK COLOR

Ammonia	1 gal.
Copper carbonate	14 oz.
Sodium carbonate	8 oz.

The copper carbonate is dissolved in the ammonia. The sodium carbonate cannot be added directly, but should be first dissolved in a very small quantity of hot water. The article to be colored is dipped in this solution until the desired shade is obtained, when it is removed and rinsed in fresh water. Boiling for a short period in a caustic potash solution fixes the color. It is then washed thoroughly, dried, lightly scratch-brushed, and lacquered.

FOR BROWN COLOR

Water	1 gal.
Caustic soda	3½ oz.
Antimony sulphide	½ oz.

The caustic soda is dissolved in hot water after which the antimony sulphide is added. This is a very fast solution, only a few seconds being required to turn the brass a dark brown.

BRONZE

A copper alloy, which is much more durable than brass, but which is employed to less extent commercially, is bronze. This alloy is a composition of copper and tin, in proportion of 85 per cent to 90 per cent of the former to 15 per cent to 10 per cent of the latter. Because of the large copper content, bronze is quite expensive, and is, therefore, not used where brass may be substituted. For electroplating work, however, bronze may often be employed to advantage.

BRONZE PLATING SOLUTION

A good bronzing solution may be prepared from the following formula:

Water	1 gal.
Sodium cyanide	6 oz.
Sodium bisulphate	2 oz.
Copper cyanide	4 oz.
Tin chloride	½ oz.

In a manner similar to the preparation of the brass electrolyte, dissolve the sodium cyanide in the prescribed quantity of water. This solution is then divided between two containers. Into one is poured the tin chloride; to the remaining solution is added the copper cyanide and sodium bisulphate. The tin chloride solution is added to the copper bath until the desired color is obtained.

BRONZE ANODES

Either cast or rolled anodes are available for bronze plating. The cast type is usually preferred. The anode area should exceed the surface to be plated.

VOLTAGE REGULATION

A lower voltage may be used for bronze plating than is required for brass work. In most cases a pressure of two to four volts is sufficient to obtain the desired current density.

COPPER

Copper fills an important place in the world's industries, especially those relating to the production and maintenance of electrical machinery. It is a very malleable metal of a reddish color. As has been previously indicated, copper enters into the composition of many of the familiar alloys, such as bronze, brass, gun metal, german silver, bell metal, and aluminum bronze. The art of copper plating has advanced to a great degree in recent years, especially in the preparation of electrotype plates. A copper coating is also quite often deposited on baser metals as a foundation for other metals, such as nickel and silver.

COPPER PLATING SOLUTIONS FOR STILL TANK

There are two divisions of copper plating electrolytes: alkaline and acid. The former finds the greater use, although more difficult of management than the acid bath. Such metals as iron, tin, and zinc are electro-positive with respect to copper, and an acid solution cannot be used in the deposition of copper upon

them. On the other hand, the acid bath is invariably used for the plating of brass and other metals less positive than copper, as well as for electrotyping.

An alkaline formula which yields a solution producing a fine grained deposit of copper is:

Water	1 gal.
Sodium cyanide	3½ oz.
Copper cyanide	3 oz.
Sodium carbonate	2 oz.
Sodium hyposulphite	¼ oz.

The plating tank should be filled about one-third full of hot water. The other ingredients should be added and dissolved in the following order: sodium cyanide, copper cyanide, sodium carbonate, and sodium hyposulphite. Finally, enough water should be poured in to fill the tank to the desired level. It is usually best to wait a short time for the solution to clear before starting the plating operation.

A very simple acid-copper plating bath may be compounded as follows:

Water	1 gal.
Copper sulphate	5 oz.
Sulphuric acid	1 oz.

The quantity of any of the three may be varied to a slight degree to obtain the desired results.

CATALYTIC AGENTS

It is difficult to determine why certain substances when added to electrolytic solutions tend to increase the current density and to produce a smooth fine-

grained deposit. Experience shows the very interesting fact that the addition of glue, gelatine, glucose, or grape sugar in small quantities to the plating bath produces very desirable working conditions. The United States Bureau of Standards is carrying on extensive experiments of this nature. It is reported that one part of glue in ten thousand parts of solution produces a noticeable effect. It is, therefore, suggested that minute quantities of any of the mentioned or similar catalytic agents be added to the acid bath.

COPPER ANODES

Anodes for use in copper plating may be in plate form. Often sheets of copper, cut to suitable size, will suffice. One difficulty met with, especially when cyanide solutions are used, is the coating of the anode surface with a substance which is a non-conductor of electricity. This condition necessitates frequent removal of the plates for cleaning.

VOLTAGE REGULATION

For still tank deposition the plating voltage may vary from two to four for the cyanide bath and from ½ to 1½ for the acid electrolyte. In barrel plating the current pressure required is often as high as ten volts for alkaline solutions, although it may be less for acid baths.

COPPER DEPOSITION

While there is ordinarily nothing difficult about copper plating, under certain conditions special care must be exercised. It is suggested, for instance, that sand blasting be employed in the preparatory clean-

ing process instead of pickling. Unless such precautions are taken in the cleaning of castings, for example, weak spots may appear in the coating. For such work no advantage is gained, if the first deposition was in an alkaline bath, by completing the plating operation in an acid solution, although this is the usual procedure for articles leaving the cyanide electrolyte in perfect condition. Furthermore, a good durable coating of copper must always be deposited on iron, tin, and zinc articles in an alkaline bath before transferring them to the acid solution where a heavy deposit can then be built up quickly.

COPPER STRIKING

A quick and positive method of cleaning work for the plating process is copper "striking" or "flashing." This was described in Chapter VII. Not only does the gas thrown off at the surface of the article clean the piece, but a light film of copper is deposited forming a perfect foundation for the deposition of any metal. The tank is of iron and forms the positive or anode plate. The article is connected to the negative bus bar of the supply circuit. The solution used for this process is:

Water	1 gal.
Sodium cyanide	1½ oz.
Copper cyanide	½ oz.
Caustic soda	8 oz.

The sodium cyanide is dissolved in the water, after which the copper cyanide and caustic soda are added.

This solution is worked at a high current density

with a voltage of about ten. A fine film of copper will be deposited in but fifteen to twenty seconds.

COPPER COLORING

Many pleasing and artistic effects may be secured by coloring copper-plated surfaces with various chemicals. The article to be colored is cleaned in the usual manner, immersed for a few moments in a muriatic-acid dip, and copper plated. Upon coming from the plating bath, it is rinsed thoroughly and suspended in the coloring solution for a length of time dependent upon the shade desired. When removed from this solution the work is carefully rinsed in clean water and lightly scratch-brushed. For hardware and office fixtures the appearance is often improved by "spotting" in several places with cloth or felt "buffs." The finished surface may then be preserved with lacquer.

A coloring solution producing a dark bronze effect is composed of:

Water	1 gal.
Potassium sulphate	8 oz.

A smaller quantity of potassium sulphide may be used or ammonium sulphide may be substituted for the potassium sulphate.

Green colors on copper may be secured by painting the work with a solution composed of:

Vinegar	1 quart
Copper carbonate	16 oz.
Ammonium chloride	8 oz.
Cream of Tartar	4 oz.

Unlike the treatment with other solutions, this work is not rinsed after immersion or painting. The liquid is allowed to dry on the article as slowly as possible; thus giving the chemicals an opportunity to act upon the copper. After the desired finish is secured, the surface is brushed lightly with softened bee's wax.

GOLD

Gold is a malleable yellow metal. Due to its chemical inactivity, it is able to resist decomposition by the atmosphere and most acids. It is employed to a great extent in the arts, but is not used in the pure condition on account of its softness. The chief alloy of gold is copper, the latter imparting a reddish color as well as increasing its hardness. The composition of gold usually employed in jewelry is measured in carats, twenty-four carats being the pure metal. Several of these alloy combinations are: 20-carat gold, equivalent to 20 parts of gold to 4 of copper; 18-carat gold, equivalent to 18 parts of gold to six of copper. The total number of parts, as may be seen, is always twenty-four.

GOLD PLATING SOLUTION

A good gold solution may be composed of:

Water	1 gal.
Gold chloride	3 oz.
Potassium cyanide	10 oz.

The potassium cyanide is dissolved in warm distilled or rain water. To this solution is added the gold chloride. The quantity of potassium cyanide may need to be varied to secure the desired color.

GOLD ANODES

While a strip of platinum may be used as an anode, the metal contents in the solution being replenished by the addition of gold chloride, it is better to employ a thin sheet of pure gold.

VOLTAGE REGULATION

A current pressure, varying from ½ to 4 volts, is required for gold plating. Experience with a particular solution will soon show the exact voltage necessary for the desired color and speed of deposition.

GOLD DEPOSITION

It is best to work the plating solution at a temperature of about 125° F. A faint film of gold is first deposited and the article lightly scratch-brushed, to lay down the grain. The work is then thoroughly washed in hot water, dipped in cold water, and immersed again in the plating solution for the final coating. It is a good plan to keep the work in motion by swinging it slightly on its slinging wire.

When it is necessary to gold plate or gild the inside of hollow vessels, the following method may be employed. The vessel is filled with the gold solution to the level desired and connected to the negative terminal of the current supply. An anode of gold is then lowered into the solution, care being taken to see that the copper connecting wire is not also immersed.

The deposition is continued in a manner identical with the method used for still-tank plating.

The finish of the completed coating may, in some

degree, be governed by the condition of the surface prior to deposition. Frosted or satin finishes are thus the direct result of sand-blasted or scratch-brushed surfaces. The sand blast should be operated at a low air pressure (about five pounds per square inch), and if possible, a fine grade of pumice should be used instead of the regular sand.

In the matter of the color of the deposit gold is very sensitive to changes in the current density, the temperature of the bath, and the composition of the plating solution. Many beautiful tints, such as rose, red, green, and the like may be secured by using special solutions. Such solutions are available on the market and since the directions for their use are peculiar to each, and are furnished by the manufacturer, they need not be discussed here.

STOP OFF VARNISH

When several colors of metal are desired on one article, special measures must be taken. The lightest shade desired is first deposited over the entire piece. After washing and drying, those sections which are to remain the light color are covered by painting with a "stop off" varnish. A soft camel's-hair brush should be used for this work. As soon as the varnish is dry the article is washed, dipped in a warm caustic potash solution to remove any existing stains, rinsed, and placed in the solution prepared to give the other color desired. After gilding, the varnish is removed by dissolving with turpentine or benzine applied with a soft brush. The "stop off" varnish may be purchased in the grade required for any specific work.

IRON

Iron is a hard, gray-white metal which is seldom available in a pure state. Steel is produced from iron by a special process. Both of these metals are of the greatest importance in the industrial world. While the electroplater deposits other metals upon steel and iron objects, he has practically no demand for iron-plated articles. For this reason but little space will be given here to the deposition of iron.

IRON PLATING SOLUTION

A formula which resembles that to be suggested later for nickel plating may be made up as follows:

Water .....1 gal.
Ferrous ammonium sulphate .....14 oz.

The ferrous ammonium sulphate is dissolved in hot water. The solution should be neutral or very slightly acid.

IRON ANODES

The anode surface should be in excess of the area to be plated. Absolutely pure iron is difficult to obtain, but the purest available should always be used. If the anodes show a tendency to become covered with a black substance, they should be removed and thoroughly cleaned.

VOLTAGE REGULATION

Because of the ease with which hydrogen is liberated in iron solutions, the current density should be

quite low. Less than one volt current pressure is sufficient for most solutions. Since iron deposition is quite similar in many respects to the more commonly-known nickel plating, it is suggested that the discussion of the latter be read before considering the former.

LEAD

Lead is a soft bluish-gray metal which melts at the comparatively low temperature of 617° F. Unless exposed to the atmosphere, lead shows a high luster. Until recently, the electroplater was little interested in the deposition of lead. At present, however, metal containers are frequently required to be lead-lined; this is easily accomplished by filling the vessel with the correct electrolyte, immersing lead anodes connected to the positive supply circuit, and using the container as a cathode.

LEAD PLATING SOLUTION

An excellent electrolytic solution for the deposition of lead is prepared in the following manner:

Water	1 gal.
Hydrofluoric acid	32 oz.
Boric acid	12 oz.
White lead (lead carbonate)	16 oz.

The hydrofluoric acid is placed in a wood container. The boric acid is then added slowly. This operation should be performed in the open or under a ventilating hood since the fumes should not be inhaled. As soon as the boric acid is dissolved, the white lead may be added, followed by the required quantity of water.

As explained in the discussion of copper plating, the addition of very small quantities of glue tends to improve the character of the deposit. And this is especially true in lead plating.

LEAD ANODES

Only anodes of pure lead should be used for deposition. They can be used in the form of castings, but lead plates or sheets are more often employed.

VOLTAGE REGULATION

As stated in a previous chapter, solution agitation allows a greater current density. The most simple method of agitation is the release of compressed air from a tube in the bottom of the tank. Experience indicates that such agitation is of little help in lead plating, yet any form of mechanical agitation somewhat improves the texture of the deposit. Heating the solution produces the same results. Again, a more concentrated solution gives a fine-grained deposit since it allows greater current density. Under normal conditions, however, the voltage required is six, provided there is solution agitation.

NICKEL

Nickel is a hard, brittle, white metal. Because it is capable of taking a high polish, it is extensively used in electroplating for deposition on the baser metals. Again, it is not easily corroded by the atmosphere and is, therefore, a valuable protective metal for iron articles.

SOLUTIONS FOR STILL TANK PLATING

A solution for nickel plating may be compounded as follows:

Water	1 gal.
Nickel ammonium sulphate (Double salt)	12 oz.
Nickel sulphate (Single salt)	2 oz.
Boric acid	2 oz.
Ammonium chloride	1 oz.

The double nickel salt is dissolved in hot water. To this solution is added the single nickel salt and ammonium chloride. The boric acid is dissolved separately in hot water before it is mixed with the solution previously prepared.

A more generally known, and certainly more simple, nickel-plating bath may be formed from:

Water	1 gal.
Nickel ammonium sulphate (Double salt)	14 oz.
Boric acid	2 oz.

The nickel ammonium sulphate is dissolved in hot water, then a quantity of the latter is added to the solution until a hydrometer reading shows a density of about 7° Baumé.

SOLUTION FOR BARREL NICKEL PLATING

For barrel nickel plating, a slightly different solution is suggested. Such an electrolyte is made up as follows:

Water	1 gal.
Nickel sulphate (Single salt)	12 oz.
Boric acid	4 oz.
Ammonium chloride	2 oz.
Muriatic acid	½ oz.

To the water is added the single nickel salt and the ammonium chloride. The boric acid is dissolved separately in a small quantity of hot water and then added to the general solution with the muriatic acid.

BLACK NICKELING

A solution quite similar to that used in bright nickel plating, yet which produces a dead-black deposit, is composed of:

Water	10 gal.
Nickel ammonium sulphate (Double salt)	5 pounds
Sulpho-cyanide of soda	1½ pounds
Sal ammoniac	1½ pounds
Zinc sulphate	1 pound
Sodium carbonate	4 oz.

The double-nickel salt is dissolved in the water. The others are then added in the following order: Sal ammoniac (Ammonium chloride), zinc sulphate, sodium carbonate, and finally, sulpho-cyanide of soda.

NICKEL ANODES

Nickel anodes, 99 per cent pure, may be secured commercially. Nothing is quite so important in nickel plating as pure nickel anodes, since even traces of

other metals, particularly copper, tend to discolor the deposit. Anodes are available in either cast or rolled form. The great advantage of the cast anode is its porous composition, which makes it readily soluble. When rolled anodes are employed, their hardness prevents their going into solution to such an extent that the electrolyte is weakened and additional nickel salts must be added to maintain the required strength.

VOLTAGE REGULATION

Nickel plating solutions offer considerable resistance to the passage of an electric current and for this reason a voltage of 2½ to 5 is often required for still-tank work. A rough, crystalline deposit is the result of a heavy current.

Barrel nickel plating requires a current pressure of about 10 volts. Because of the constant solution agitation, a high-current density is permissible.

The current pressure necessary for black-nickel plating is quite low, ½ volt being sufficient to produce the best results.

PREPARATION OF WORK FOR NICKEL PLATING

The preparation of work for plating was discussed to some extent in Chapter VIII. A few brief remarks on the preparation of articles to be nickel-plated might nevertheless, be added at this time. There are two essential requirements: A smooth, polished surface, and a preliminary coating of some metal less positive than nickel. A deposited nickel coating is very hard. For this reason it is desirable to eliminate the need of as much polishing work as possible. A preliminary surface that has been polished until

it is smooth as the desired finish of the completed coating, will assist greatly in producing a perfect deposit. Moreover, such careful preparation of the surface permits the elimination of pickling and acid-dipping operations which later appear to have a detrimental effect on the nickel deposit. While it is possible to deposit nickel directly upon iron, steel, zinc, tin and other metals more electro-positive in nature to nickel, better results are obtained by first giving articles of those metals a light coating of copper or brass. In many instances, "striking" in the copper bath described in this chapter, is sufficient

NICKEL DEPOSITION

More than usual care is necessary in the management of nickel solutions. In general, there are five items which influence the character of the deposit. They are: cleanness, metal content of solution, acidity of solution, temperature of solution, and current strength.

Cleanness is required in any branch of electroplating, but in nickel deposition it is absolutely essential. Unless precautions are taken, dust that has settled on the surface of the solution will adhere to the work as it is immersed. Obviously, there will be an inferior deposit at the points covered by the dust and the finished surface will show small "pin holes." Again it must be remembered that because of its neutral reaction, the nickel solution does not have the chemical strength to dissolve light films of oil or grease, which cyanide or acid electrolytes of other metals do to some extent. Thus, even the touch of a finger renders the work unclean for the nickel-plating bath. Hence,

the necessity for special care in the scouring and preliminary cleaning process. To insure rapid dry-

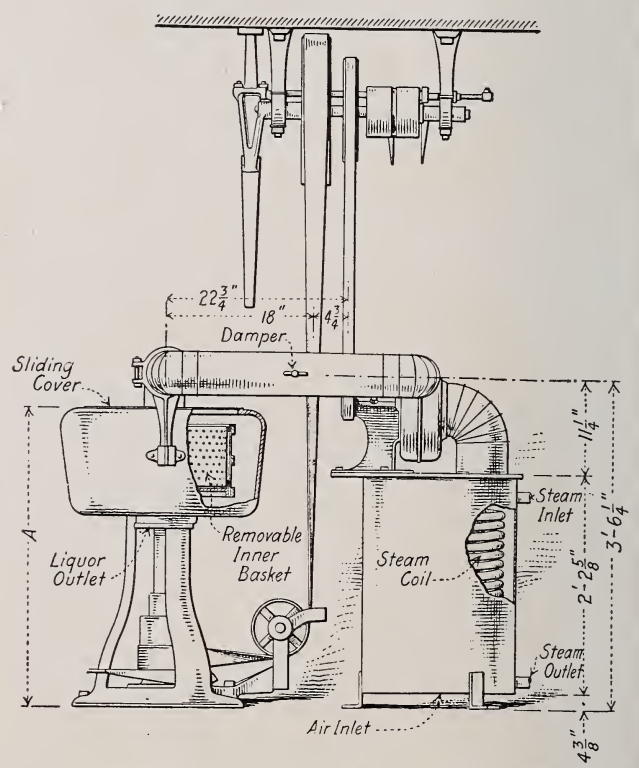

Fig. 105.—Metal Drying Apparatus. Work Taken From the Plating Tank is Rinsed in Fresh Water and Placed in This Machine for Quick Drying

(General Platers' Supply Co.)

ing after cleaning, the work is placed in special machines, as shown in Figs. 105 and 106.

The hydrometer is a valuable aid in determining

the content of the nickel-plating bath. A reading of 6° to 8° Baumé indicates that the metal content is sufficient. Any reading below 5° denotes a weak solution and more single nickel salts should be added. This weak condition is usually the result of the use of rolled anodes or insufficient active anode surface.

Success in nickel plating requires that the solution be very slightly acid. One of the chief causes of "peeling" or "blistering", however, is an excess of acid, so care must be taken to see that only the necessary quantity of acid is used to bring about the desired reaction. A bath showing an alkaline reaction produces discolored, dark work. Litmus paper, which was described in Chapter VI, has the property of turning red when dipped in an acid solution, and blue when exposed to an alkaline bath. Although the double nickel salt in solution is usually neutral, a few drops of sulphuric acid may be added until the solution shows a slight acid reaction, when tested with litmus paper. Should it appear that the electrolyte is too strongly acid, then more neutral salts are added until the correct reaction is obtained.

A subject that receives but little attention, yet which has as much, if not more, to do with success or failure in nickel plating than any other one condition, is the temperature of the solution. A temperature below 50° F. is apt to cause crystallization of the salts. Usually a certain quantity of hydrogen is liberated at the cathode; the temperature must be regulated for each solution so that the quantity of these gas bubbles is not excessive and thus cause the metal to "pit." If the plating tanks are equipped with steam-heating coils, similar to those described in

Chapter V, the temperature may be regulated with little difficulty.

A very strong current also causes excessive liberation of hydrogen which, as has already been stated, is one of the chief causes of "pitted" and uneven deposits. Only experience with each particular solution will show the current density required for successful work.

Reference was made earlier in the chapter to the use of certain catalytic agents. Glue cannot be used in nickel-plating solutions, since it causes a brittle deposit which flakes off readily. Glucose, however, has no such detrimental effect but rather produces a smooth fine-grained deposit.

SILVER

Silver is a white metal, having a high lustre. It is malleable and can therefore be rolled or beaten into very thin sheets. It is a harder metal than gold, but softer than copper. While it is not acted upon by the air or water, it combines with sulphur to form black silver sulphide. Thus the surface of silver-plated articles, exposed to smoke or gas containing traces of sulphur, is tarnished with the black sulphide. Silver presents the least resistance, of all metals, to the flow of electricity.

SILVER PLATING SOLUTIONS

A simple formula for a silver plating solution is prepared as follows:

Water	1 gal.
Silver chloride	3 oz.
Sodium cyanide	8 oz.

The sodium cyanide is dissolved in warm water. To this solution is added the silver chloride which has been reduced to a paste with water. Another quite similar formula substitutes potassium cyanide for the sodium cyanide. It may be necessary to add more cyanide to secure the proper working conditions of the bath. It is well, though, to use the cyanide with discretion; an excess will discolor the deposit as well as make the plating process sluggish.

SILVER ANODES

Rolled anodes of fine silver are usually employed. The purity of the metal influences the deposit and only the purest silver should therefore be used for anodes. While it is not absolutely essential, the anode will pass into solution with greater ease if it be annealed prior to placing in the bath.

VOLTAGE REGULATION

The required current pressure is exceedingly low for silver plating, but ½ to 1 volt being sufficient. The average current density is approximately 2½ amperes per square foot of surface plated.

SILVER DEPOSITION

The work to be silver plated is cleaned in the usual manner so that all grease, oxides and other tarnish are removed. For iron and steel articles, a copper film may be deposited to form a foundation for the silver. More often, however, a silver "strike" is used. The work is dipped for a moment in a hot potash bath and then transferred, without rinsing, to the "strike" solution. This bath is usually similar to those described in the paragraph on silver plating

solutions, with the possible exception that there may be an excess of cyanide and a decrease in the metal content. A very strong current is used with the result that a thin adhesive film of silver is quickly deposited. The work may then be lightly scratch-brushed, rinsed and immersed in the regular vat for the completion of the deposition process. Tin, zinc, and their alloys may also receive the foregoing preliminary treatment before entering the plating tank. Copper and metals containing a large percentage of copper are sometimes prepared by dipping in a solution of potassium cyanide to which a small quantity of mercuric oxide has been added. The article, chemically cleaned in an acid dip, is immersed for a few moments in this solution. Upon removal it will be seen that a thin coating of mercury has adhered to the surface. The article, thus treated, is suspended in the standard solution for the silver plate.

SILVER COLORING

It is sometimes desired to color silver-coated articles. Silver surfaces which have been colored a blue-black may be "spotted" on a soft cloth wheel to obtain varying shades, or the embossed portions may be brightened, leaving the background the original color. The following is the usual so-called "oxidizing" solution for silver coloring:

Water	1 gal.
Ammonium carbonate	2 oz.
Potassium sulphide	1 oz.

If a hot solution is employed, only a few seconds are required to color the silver.

TIN

Tin is a soft, malleable, white metal. Its chief uses, commercially, are in the formation of alloys and as a protective coating for vessels. While tin plating is not extensively employed in the industrial world, yet, under certain conditions, tin deposition is quite essential. Usually, however, the coating is secured at less cost by merely dipping the article in molten tin.

TIN-PLATING SOLUTIONS

A satisfactory tin-plating solution is made up of:

Water	1 gal.
Caustic soda	16 oz.
Sodium hyposulphite	8 oz.
Tin chloride	4 oz.
Sodium cyanide	2 oz.

The water is placed in three containers, an equal amount in each. The caustic soda is dissolved in the first; the sodium hyposulphite in the second; the sodium cyanide in the third. A little water is added to the tin chloride and then worked into the consistency of paste. The caustic soda and sodium hyposulphite solutions are poured together. To this mixture the tin chloride is added followed by the sodium cyanide solution. A very small quantity of glue should also be used if a fine close-grained deposit is desired.

TIN ANODES

Cast anodes are usually employed for tin plating, although other types can be used with success.

VOLTAGE REGULATION

There may be a wide variation in the current pressure, the best results being obtained with voltages ranging from two to six.

TIN DEPOSITION

Little difficulty is experienced in the management of tin-plating solutions. The preparatory cleaning solutions are identical with those described in Chapter VII. If glue, or any of the other catalytic agents previously mentioned, is added to the solution, even heavy deposits may be secured without trouble.

ZINC

Zinc is a bluish-white metal which at ordinary temperatures is quite brittle. When heated to 212° F, it becomes malleable as well as ductile and may be rolled into sheets. Above 424° F., however, it becomes brittle again, and finally melts at about 775° F. In this zinc is peculiar.

ELECTRO-GALVANIZING

Zinc is widely employed as a protective coating for such metals as are affected by the atmosphere. Until recently, a process known as hot galvanizing was employed in all instances where this film of zinc was required. As the term implies, this method required the immersion of the work in molten zinc, which had a deleterious effect on those metals whose characteristics were changed by an increase in temperature. Of late, however, much progress has been made in the electro-deposition of zinc, often termed "cold gal-

vanizing'' or '' electro-galvanizing''. Because zinc is electro-positive to iron and steel it is especially valuable as a protective coating for these metals. Unlike hot galvanizing, the electro-deposited coating of zinc may be varied in thickness and is certainly smoother and more durable.

SOLUTIONS FOR STILL TANK ZINC PLATING

As is the case with copper, there are two kinds of zinc-plating solutions available for still-tank work: acid and alkaline. An acid solution which has met with favor is composed of:

Water	1 gal.
Zinc sulphate	32 oz.
Aluminum sulphate	2 oz.
Ammonium chloride	2 oz.
Sulphuric acid	¼ oz.

The zinc sulphate and ammonium chloride are dissolved in part of the water while the aluminum sulphate is dissolved in the remainder. The two solutions are then mixed together and the specified quantity of sulphuric acid is added. Grape sugar may be used as a catalytic agent to prevent roughness in the deposit.

Another formula, quite similar to the above and which is prepared in the same manner, is:

Water	1 gal.
Zinc sulphate	32 oz.
Aluminum sulphate	4 oz.
Ammonium chloride	2 oz.
Boric acid	2 oz.

An alkaline or cyanide zinc solution does not deposit the metal as rapidly as the acid bath, but the coating is more uniform. A formula for such a solution is:

Water	1 gal.
Zinc cyanide	3 oz.
Sodium cyanide	3 oz.
Caustic soda	4 oz.
Aluminum sulphate	¼ oz.

The sodium cyanide and the zinc cyanide are dissolved in a portion of the water. The aluminum sulphide is dissolved in the remaining part in another container. The two solutions are then mixed together. When the tank has been filled to the proper depth, the caustic soda is added.

Another very good solution, which in composition and preparation is similar to the foregoing, is:

Water	1 gal.
Zinc cyanide	4 oz.
Sodium cyanide	4 oz.
Caustic soda	4 oz.
Ammonium chloride	2 oz.

Cyanide solutions usually work best when their temperatures are raised above 150° F.

SOLUTIONS FOR BARREL ZINC PLATING

Many small iron and steel articles may be quickly protected against rust by receiving a light coating of zinc in a plating barrel. Solutions for barrel plating vary but little from those required for still-tank work, but the following formula is recommended:

Water	1 gal.
Zinc sulphate	48 oz.
Aluminum sulphate	3 oz.
Ammonium chloride	3 oz.
Sulphuric acid	½ oz.

The chemicals are dissolved in water and the solutions combined in the same manner as specified for acid-zinc baths for still-tank plating.

There are a great number of formulæ for zinc plating, but those given here undoubtedly produce the best results with the least expense and effort.

ZINC ANODES

For zinc plating a cast anode is preferred. It may be round, flat, elliptical or corrugated in form. The purest metal obtainable should be used for the anodes if perfect deposits are to be expected. The anode surface should be at least one-third greater than the area to be plated.

VOLTAGE REGULATION

The current pressure for acid solutions for still-tank work may vary from 3 to 6 volts, while for cyanide solutions the pressure may range from 2 to 4 volts. Barrel plating always requires a much higher current pressure, and for zinc deposition should be 10 to 12 volts. Other types of mechanical plating also require a high-current pressure of 8 to 10 volts.

ZINC DEPOSITION

There is little to say as to special precautions to be taken in the management of galvanizing solutions.

If the work has been carefully cleaned no difficulty will be experienced in obtaining a perfect coating. The only possible exception to this statement is the handling of iron castings which, because of their porous nature, are difficult to clean. The best solution

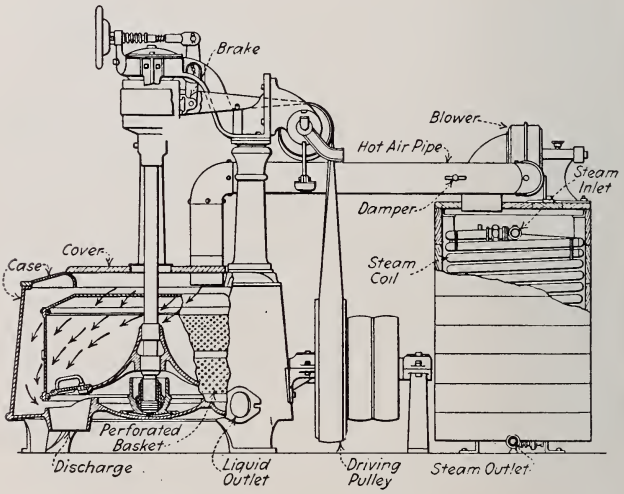

Fig. 106.—Metal Drying Apparatus Arranged with Bottom Discharge

(General Platers' Supply Co.)

to the problem, in this instance, is to clean them electrically in an alkaline bath composed of equal parts of caustic soda, sodium cyanide, and sodium carbonate dissolved in water. The tank should be of steel since it composes the anode. The casting is connected to the negative line and acts as the cathode. A current pressure of 6 to 8 volts is sufficient to clean the

work in a few minutes, provided the action of the gas thrown off at the surface of the casting appears vigorous. Sand blasting is also an excellent method of cleaning work for zinc plating, no chemical treatment being required after such an operation.

MECHANICAL MACHINERY FOR ELECTRO-GALVANIZING

While automatic machinery is employed in the deposition of many metals, the greatest number and variety is found in machines designed especially for electro-galvanizing. The subject of galvanizing is one so broad that it cannot be discussed in this volume. Merely casual observation of the iron and steel articles about us in our homes, in the industries, on the farms—shows that the majority are protected from rust and other corrosion by galvanizing. To compete with the low cost of hot galvanizing, automatic plating machinery must be used, thereby allowing quantity production. The commercial electroplater, who finds a demand for such work, will be wise to study the modern plating machinery to determine the extent to which such devices would increase the quality and quantity of his output.

CHAPTER IX

POLISHING, BUFFING AND LACQUERING

The Polishing Room—The Motor Driven Lathe—The Belt-Driven Lathe — Overhanging Lathes — Belt Strapping —Grinding Lathes—Surface Grinders—Portable Grinders—Dust Collector Hoods—Polishing—Polishing Wheels —Gluing the Wheels—Cleaning the Wheels—Emery Applications—The Glue Heater—Emery Trough—Buffing—Buffing Wheels—Buffing Compositions—Speed of Buffs—Scratch Brushes—Burnishing Barrel—Lacquering—The Lacquer Room—Lacquer Application—Colored Lacquer.

THE POLISHING ROOM

All grinding, polishing, and buffing operations, because of the abrasive dust thrown from the wheels, must be performed in a room isolated from the plating tanks. In arranging the floor plan, several important features must be considered. The polishing lathes, for instance, must be so situated that the operators face the light as they work, thereby eliminating conflicting shadows. On the other hand, sufficient space must be allowed between the lathes for the storage of work, thus making it possible to continue operations without moving from the wheel.

Besides the polishing and buffing machines, a well-equipped polishing room should be provided with a ball burnisher, tumbling barrels, and sand-blast apparatus. These latter two have already been de-

scribed in some detail and, although they are part of the polishing-room equipment, will not require further consideration in this chapter.

Power for driving the machinery may be supplied by a motor of the correct capacity and speed. If the motor is located in the polishing room, dust-proof or protected bearings should be provided. It is seldom necessary to provide a motor for each machine; power may be transmitted to a number of machines through line shafts and counter shafts.

THE MOTOR-DRIVEN LATHE

The most simple type of polishing or buffing lathe is direct motor-driven, the armature shafts, extended beyond the bearings, serving as the arbor for the wheel. This extension may be made on either or both

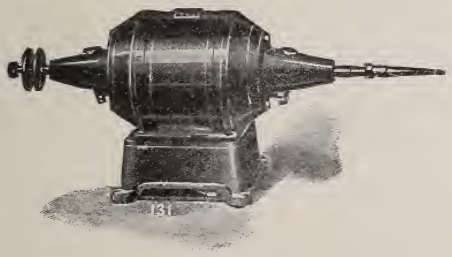

Fig. 107.—Polishing and Buffing Motor Lathe
(General Platers' Supply Co.)

sides of the motor. Particular care must be exercised in the protection of the bearings and commutator against the injurious emery dust from the wheel. A fully-enclosed motor, as illustrated in Fig. 107, should be secured, if possible. It will be noted that even

the oil holes and cups are omitted, self-oiling bearings being used.

The advantage of this single unit machine is apparent. It may be placed where most convenient, on a bench or on a column, without regard to location of overhead shafting. Again, such units may be added to the equipment without causing a drain upon the existing power plant.

THE BELT-DRIVEN LATHE

Belt-driven lathe heads form the standard equipment for many polishing rooms. According to the shop requirements, they can be secured with flat,

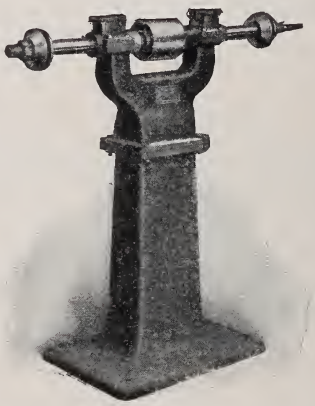

Fig. 108.—Polishing and Buffing Head on Column

(Bennett O'Connell Co.)

cone, or grooved pulleys. The bearings are dust-proof and are so constructed that adjustment for wear can be made when necessary. Ball bearings are

sometimes employed on the small machines. A column, upon which the lathe head can be mounted, can be used or the lathe can be secured to the work-

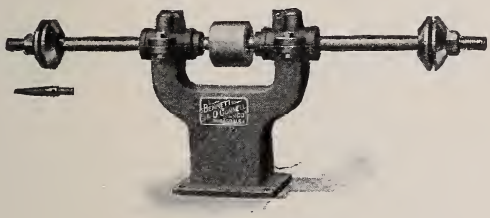

Fig. 109.—Polishing and Buffing Lathe

(Bennett O'Connell Co.)

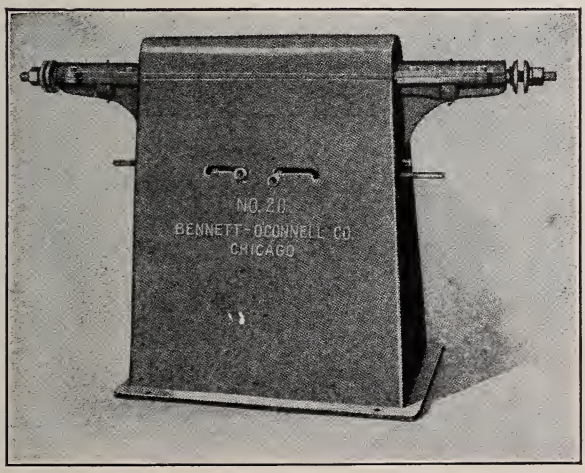

Fig. 110.—View of Lathe Arranged for Belting from Shaft Below the Floor

(Bennett O'Connell Co.)

table. The spindle ends are usually tapered with screw points, but a straight-threaded arbor may be provided if desired. The several illustrations show polishing and buffing lathes for both light and heavy

Fig. 111.—Overhanging Polishing Lathe
(A. P. Munning & Co.)

duty, that in Fig. 108 shows a polishing and buffing head mounted on a column. The simple lathe in Fig. 109 is a plain bearing form, and that in Fig. 110 is a heavier type adapted to be driven by belting from shafting placed below it.

OVERHANGING LATHES

An overhanging lathe, such as is shown in Fig. 111, is adapted to all classes of work. The overhang permits its use on large work of irregular shape, without interference with the column.

BELT STRAPPING

A belt-strapping attachment may be conveniently used in connection with a polishing head. For the wheel is substituted a flanged pulley. At a distance,

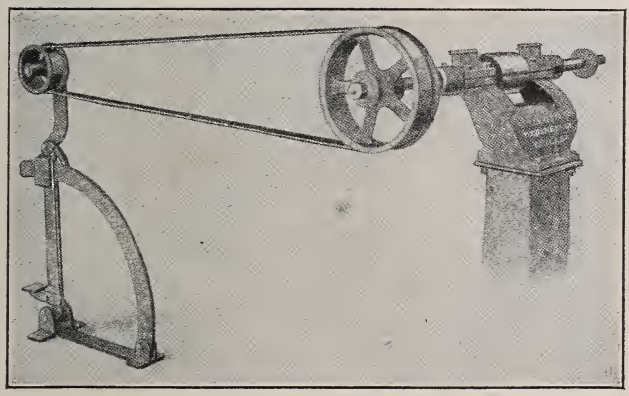

Fig. 112.—Belt Strapping Attachment

(Bennett O'Connell Co.)

depending upon the length of the belt, a second pulley support is secured to the floor. This support, as is clearly indicated in Fig. 112, may be adjusted to tighten or loosen the belt. There are many classes of work which can be polished with ease on this

device, which would be handled with difficulty on a wheel.

GRINDING LATHES

A grinding lathe is rigidly constructed, but in general appearance is similar to the standard polish-

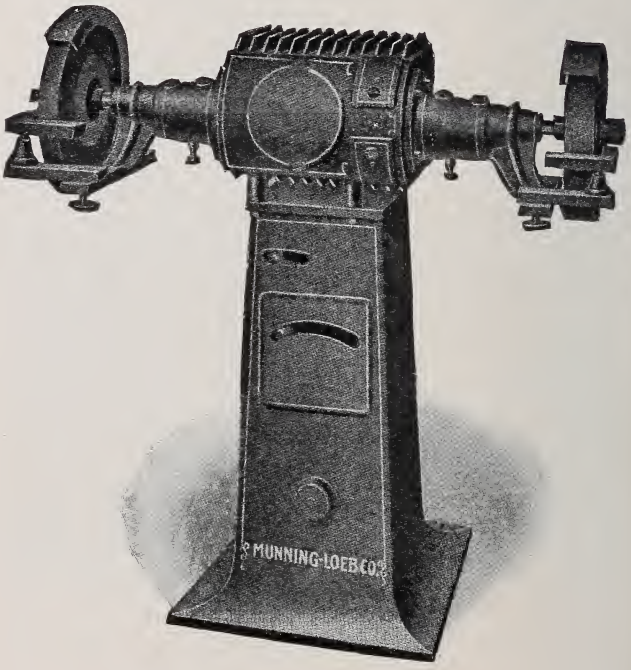

Fig. 113.—Motor Driven Grinder

(A. P. Munning & Co.)

ing head. For convenience, a rest is provided as well as a container for water. It is quite important to place substantial guards around emery or composi-

tion wheels. Such protection may save much damage to property and injury to workmen should the wheel burst while running at a high speed. Another use-

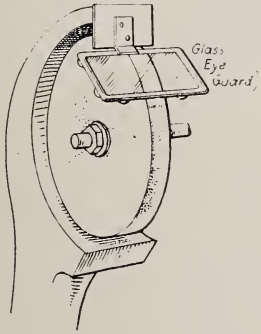

Fig. 114.—Simple Glass Shield to Protect Eyes from Emery Dust

ful device is a glass shield, Fig. 114, to protect the eyes from flying chips or dust. This shield may be easily constructed to suit any special requirements.

PORTABLE GRINDERS

For heavy castings or large objects, a portable grinding apparatus is most useful. This simple device consists of a flexible shaft equipped with a pulley at one end and a spindle at the other extremity for a polishing or grinding wheel. The pulley end is anchored to the floor. A round belt, passing between a grooved line shaft pulley and the anchored pulley, drives the polishing or grinding wheel. The

workman moves the wheel over the work instead of vice versa, as when using a lathe-mounted grinder.

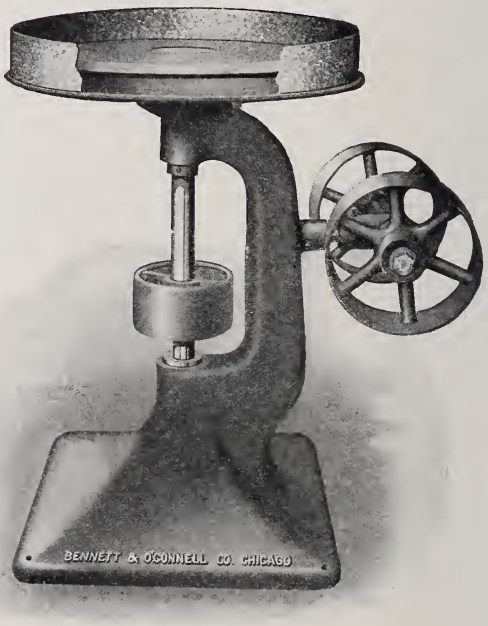

Fig. 115.—Disc Surface Grinder and Polisher
(Bennett O'Connell Co.)

SURFACE GRINDERS

A disc-surface grinder and polisher is shown in Fig. 115. As will be noted, a horizontal steel disc is secured to an upright driving shaft. A cloth circle

is cemented to the disc, sized with a suitable grain of emery. The steel disc can be easily removed, reversed, or replaced by another disc. This machine

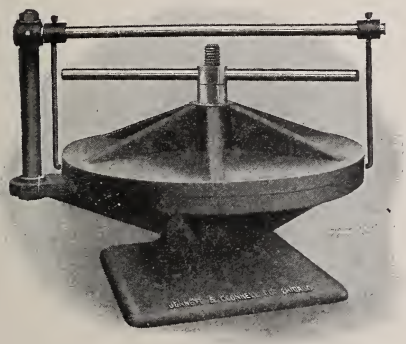

Fig. 116.—Press for Gluing Emery Cloth to Grinder Discs.
(Bennett O'Connell Co.)

is exceptionally useful for the preparation of objects presenting flat surfaces.

A special press, Fig. 116, is required for cementing the emery cloth to the steel disc.

DUST COLLECTOR HOODS

Polishing, buffing, and grinding operations produce much metallic and abrasive dust. Such dust, if not removed as soon as formed, fills the air, settles upon finished work, and injures the health of the workmen. Even though many state laws require that suitable ventilating devices be provided in rooms devoted to work of this nature, the removal of abrasive dust

should be considered also from the standpoint of efficiency. Fresh air and clean surroundings are productive of efficient work.

While open windows or roof ventilators will assist in maintaining air circulation, the only positive

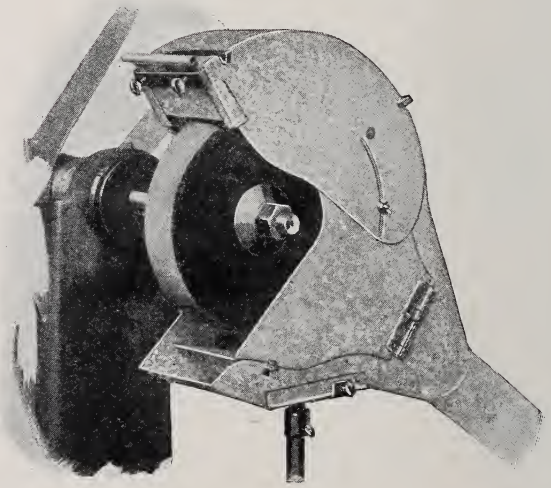

Fig. 117.—Hood with Adjustable Top

(General Platers' Supply Co.)

method is a blower system. If hoods, such as illustrated in Fig. 117, are placed around the polishing, buffing, and grinding wheels, and each hood connected through a pipe to an exhaust fan, all of the dust particles can be collected as they are thrown from the wheel. A very satisfactory motor driven fan for ventilating the plating room is shown in Fig. 118.

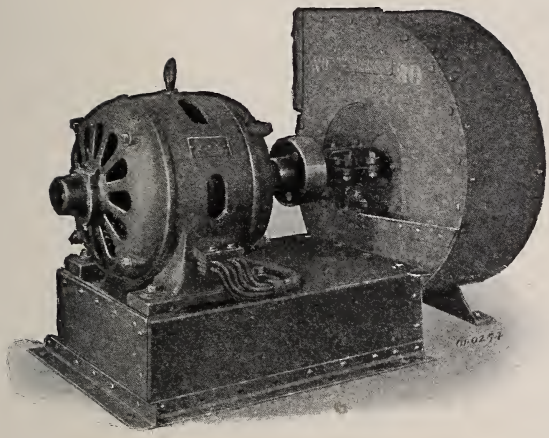

Fig. 118.—Motor Driven Ventilating Fan

(Wagner Electric Mfg. Co.)

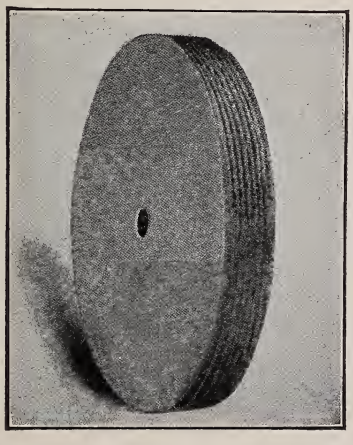

Fig. 119.—Wooden Polishing Wheel

POLISHING

The machinery required for grinding, polishing, and burring operations has been described. It is therefore necessary to consider the preparation and

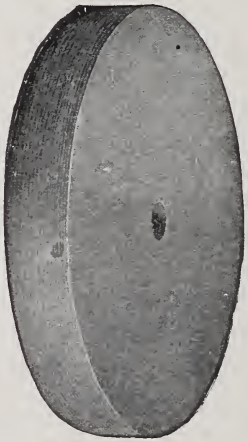

Fig. 120.—Canvas Polishing Wheel

use of the wheels employed to obtain the various surface finishes.

Polishing is accomplished with disc wheels on whose perimeter emery is set in glue. Such wheels are constructed of wood covered with leather, or formed of many layers of canvas, felt, leather or similar materials.

POLISHING WHEELS

The wooden wheel is constructed, as a rule, of ½-inch discs glued together, the alternate layers with the grain crossed, and dried under pressure. A

leather band is secured to the circumference, and it is upon this surface that the emery is glued. Wooden

Fig. 121.—Felt Polishing Wheel

Fig. 122.—Loose Sheepskin Polishing Wheel

wheels are available in any diameter over 8 inches and any thickness greater than 1 inch.

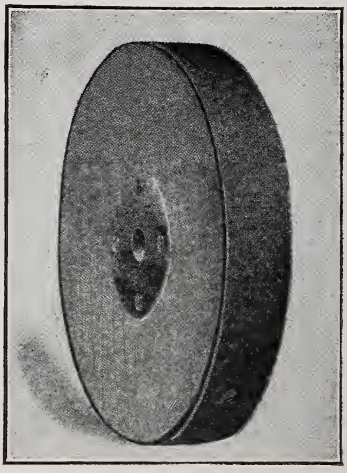

Fig. 123.—Bull Neck Polishing Wheel

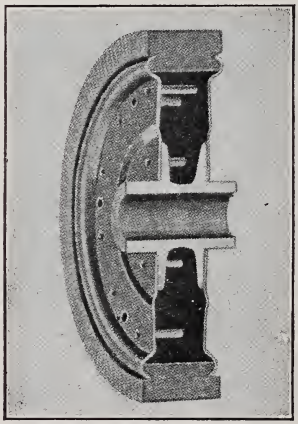

Fig. 124.—Cross Section of Compress Wheel

The canvas wheel, while often less expensive than other types, is quite serviceable. It is built up of many layers of strong, tightly-woven canvas discs cemented together. An advantage claimed for this wheel is its resilience. This assists materially in lessening fatigue of the workman.

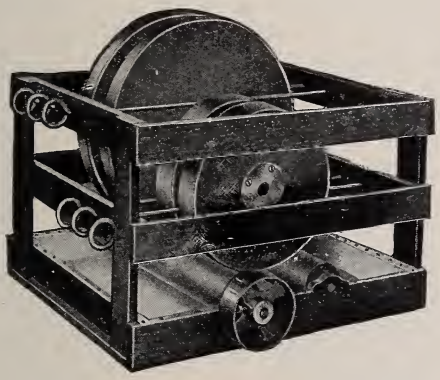

Fig. 125.—Polishing Wheel Cleaner

(Crown Rheostat & Supply Co.)

Felt, cloth, and paper wheels are sometimes used, their action being similar to the canvas.

The all-leather polishing wheel is especially adaptable to fast, hard grinding. Because of its elasticity or pliability, it quickly adjusts itself to any unevenness in the emery coating. This quality allows a longer life to the emery surface. If desired, the leather wheel may have its polishing surface so treated that it will accomplish the identical results of the emery or carborundum wheel. Again the

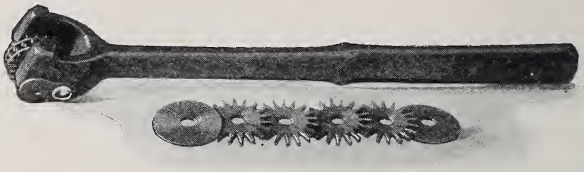

Fig. 126.—Huntington Emery Wheel Dresser for Truing Wheels While Running at Full Speed.
(Crown Rheostat & Supply Co.)

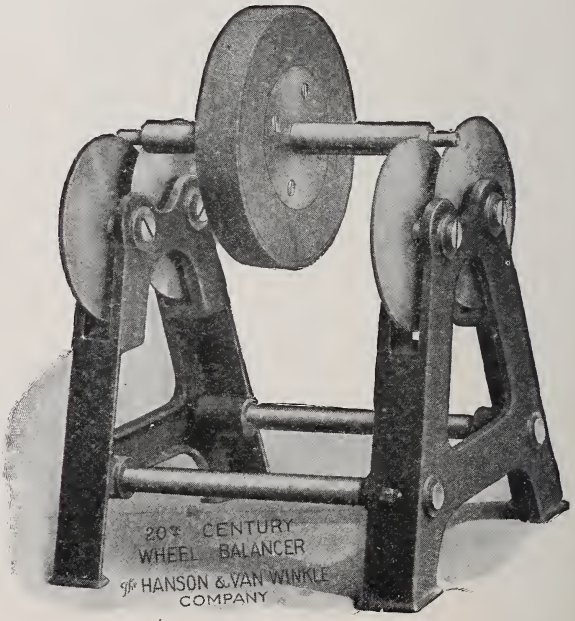

Fig. 127.—Balancing Tool for Polishing Wheels, Pulleys, Armatures, etc.
(Hanson & Van Winkle Co.)

surface may be formed to fit any particular work. For articles having irregular edges, a soft sheep-skin wheel produces the best results. Various forms of polishing wheels are shown in Figs. 119 to 124 inclusive.

CLEANING THE WHEEL

After prolonged use and many glue and emery applications, the polishing surface becomes rough and uneven. The best remedy is to remove entirely the thick coating when a new cutting surface may be applied. A polishing wheel cleaner, similar to that shown in Fig. 125, may be employed for this work. By placing the worn wheel in the machine, and allowing it to run for a few minutes with the water just touching the rollers, all of the glue and emery will be removed. Should such a device be unavailable, place the wheel on the lathe and loosen the emery particles by pressing a rough metallic edge, such as a broken casting, against the revolving wheel face. The surface may then be cut down by the aid of a wheel trimmer, an instrument which is shown in Fig. 126. It may be further smoothed by wetting the wheel with a piece of water-soaked waste or cloth held with one hand while a stone, manufactured for such purposes, is held against the surface with the other hand. As soon as the prepared surface is dry, the usual glue and emery applications may be made. A balancing stand to test the wheel for rotative balance is shown in Fig. 127.

EMERY APPLICATIONS

It may be well to add a word of caution in regard to the gluing operation. Unless some degree of care

is exercised, a wheel prepared for fine work will have a polishing surface sprinkled with a few grains of coarse emery left on it by the glue brush. Perhaps the brush or glue pot, in such instances, had previously been used in preparing a coarse emery wheel. A wheel surface containing several grades of emery cannot possibly be used with any expectation of producing fine work.

It is possible to use the same polishing wheel for either roughing or fining operations. While the wheel may be run dry for iron or steel fining it is best to apply slight quantities of tallow for brass work.

Grease wheels are usually set up with a fine grade of emery. Oil may be used with success for keeping the grease wheel polishing surface lubricated, but the emery deposit will not be as well preserved as when tallow is applied. Experience has shown that a coarse-grained material, such as cast iron, will finish with best results when No. 140 emery is used. No. 160 emery is required for the fine-grained malleable iron, drawn-steel parts, drop forgings, and the like. Old emery is removed in the usual manner and new applications are made as previously directed.

In general, it is a good policy to keep several wheels prepared and held in reserve. The extra cost is negligible in comparison to the expense of holding up production at some critical time. Without fail, all wheels should be inspected each evening, and should the examination show that new deposits are required, the polishing surfaces should be applied before closing up the shop. Thus all wheels will be dry and in good condition the following morning. Canvas

wheels, which become soft, may be hardened by first immersing the perimeter of the wheel in hot water to a depth of several inches. The wheel is then rolled back and forth so that the heat will penetrate every

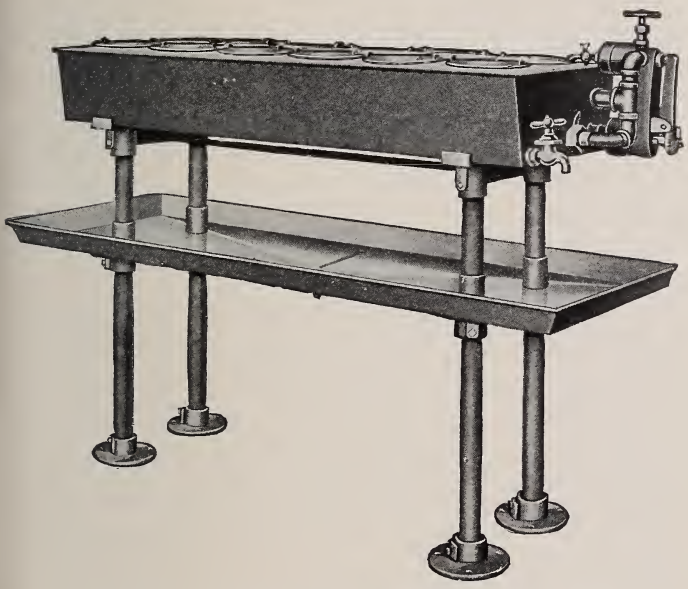

Fig. 128.—A Modern Steam Heated Glue Container

(Crown Rheostat & Supply Co.)

point on the circumference. After this operation, it is placed in a press or between two boards. If the latter are used, some heavy object should be piled upon the top board so that the wheel will dry under pressure.

THE GLUE HEATER

It is not possible to heat glue in a make-shift container and expect to secure a clear, flowing liquid free from foreign matter. Under no circumstances should the glue-pot be placed directly upon the heating element unless surrounded by a water jacket. Fig. 128 illustrates an excellent type of glue heater. It will be noticed that there are several glue containers. This arrangement allows a separate pot for each of several similar grades of emery and the danger of coarse grains mixing with finer grades through the medium of one container is eliminated.

GLUING THE WHEELS

It is a simple matter to prepare a polishing wheel, but care must always be exercised to see that the job is neatly done. If the wheel is new, several coats of glue and emery are required to build up a cutting surface. Place the wheel in the lathe, and while it is turning, use sandpaper to remove any uneven points. Apply a thin coat of hot glue, free from foreign matter. The wheel may continue running for a time until the glue is nearly hard when a wet cloth should be pressed against the revolving glued surface. This procedure will produce a smooth face for the emery coating. If the polishing lathe is not required, the wheel may remain on the arbor until thoroughly dry. A new wheel, since there is no emery body to build upon, should be given two coats of glue and emery. A drying period is allowed between the coatings.

EMERY TROUGH

There is no more simple method of applying emery to the polishing wheel than through the use of an emery trough, such as is shown in Fig. 129. A glue

Fig. 129.—Emery Trough

(Crown Rheostat & Supply Co.)

application is made to the surface of the wheel and the latter is then rolled through the trough in which is the desired grade of emery.

BUFFING

Buffing is the process of finishing metal surfaces by the use of cloth wheels charged with a special composition.

BUFFING WHEELS

Buffing wheels, more intimately termed "buffs," are constructed of less rigid material than polishing wheels. For this reason there is more "give" to them, requiring less pressure to produce the desired results. Materials such as bleached and unbleached muslin, sheeting, canton flannel, denim, and light duck are used extensively. To give maximum wear, the layers or discs of cloth are arranged with the

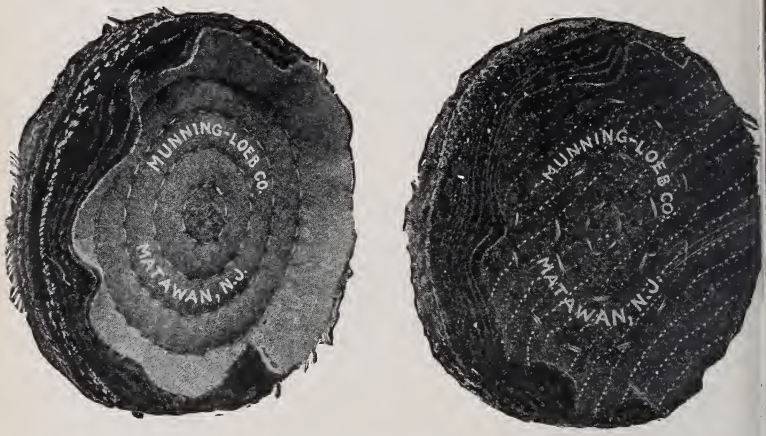

Fig. 130.—Woolen Cloth Buffs

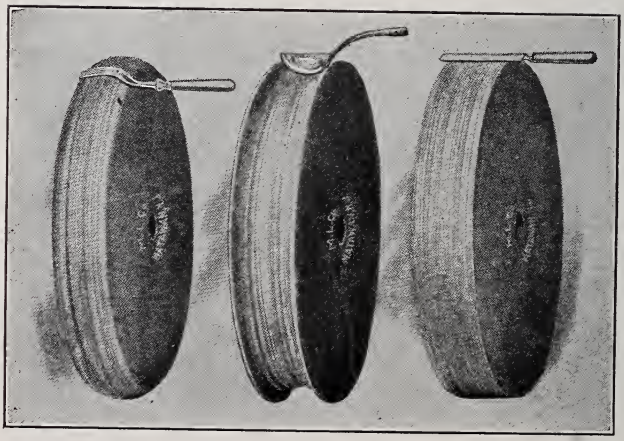

Fig. 131.—Buff Leather Wheels. Note They May Be Turned to Special Shapes to Facilitate Buffing Different Articles

threads crossing each other in different directions. A number of such discs are assembled into sections about $\frac{3}{16}$ inch thick and stitched together, the stitching being in concentric circles $\frac{1}{4}$ inch apart. Any number of these sections may then be cemented to-

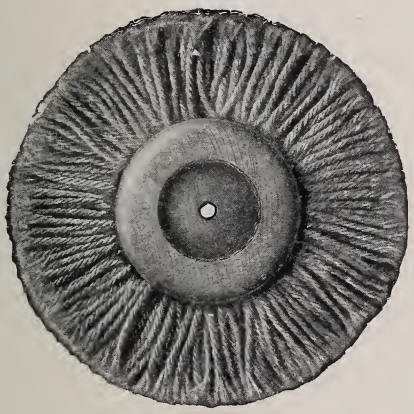

Fig. 132.—Cotton Wick Buff Wheel

gether under pressure to secure the desired wheel thickness. Typical woolen cloth buffs are shown in Fig. 130.

It is not possible here to give the type of buffs required for the various forms of work. Each manufacturer separates his product into various grades and for each he claims special advantages. While, in general, it might be said that unbleached muslin is used to best advantage in buffing silverware and other fine work, bleached muslin for brass, copper, and heavily-nickeled parts, sheeting for gold and silver, yet experience and the manufacturer's advice

will best tell the exact grade required to produce the finest results. These wheels may be formed to handle various classes of work as the buff leather wheels are in Fig. 131. A cotton-wick buff wheel is shown in Fig. 132.

BUFFING COMPOSITIONS

Various compositions may be used with buffing wheels to increase the cutting speed or assist in forming a smooth finish. Tripoli, crocus, pumice, lime,

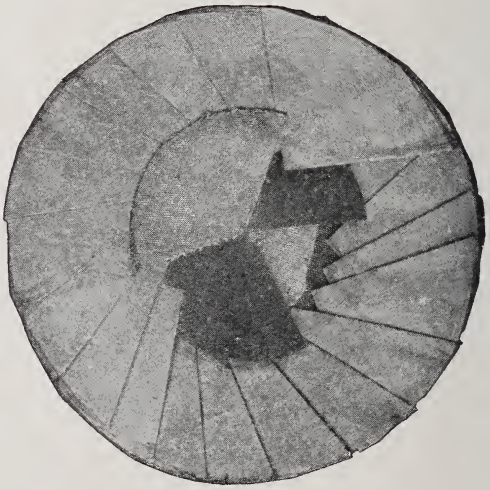

Fig. 133.—Stubless Triplex Buff

and rouge, marketed perhaps under a trade name, are all efficient. Tripoli is a silicious substance and an excellent abrasive. There is nothing in its composition to assist in holding the particles together or to make it cling to the wheel surface. Tallow or other grease is therefore mixed with the tripoli for con-

venience in applying the composition. It can be obtained in many degrees of fineness.

Crocus is a red iron oxide. It is prepared in both

Fig. 134.—Lump Pumice

(Crown Rheostat & Supply Co.)

powder and cake form. Crocus is used on work requiring a high polish and fine finish.

Pumice stone, as its name implies, is composed of pumice usually imported from Italy. Very excellent "old brass" finishes may be obtained with its use.

Lime compositions can be obtained in powder form ready to mix with grease or water. While they are especially good compounds for nickel, copper alloys can also be readily finished with them to a high luster.

Rouges, formed from oxides, are usually red or black in color. Red rouge is the most popular and is used for coloring and fine polishing. Black rouge is manufactured for buffing materials on which the red color would be objectionable.

Rotten stone may be obtained in both powdered and

lump form. It has much the same characteristics as the foregoing abrasives.

Emery can be obtained in cake form, the emery being mixed with the hard grease of the cakes. It

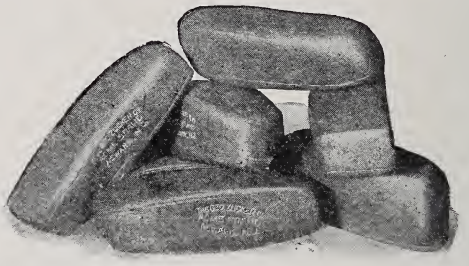

Fig. 135.—Finishing Composition in Cake Form
(A. P. Munning & Co.)

may also be secured, as is the case of the other compositions, in barrel quantities, the mixture of grease and abrasive having the same qualities as are found in the cake form.

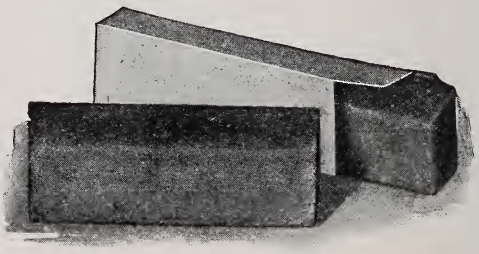

Fig. 136.—Cutting Down Composition in Cake Form
(A. P. Munning & Co.)

Lump pumice is shown at Fig. 134 and the crocus composition used for coating buffing wheels is made

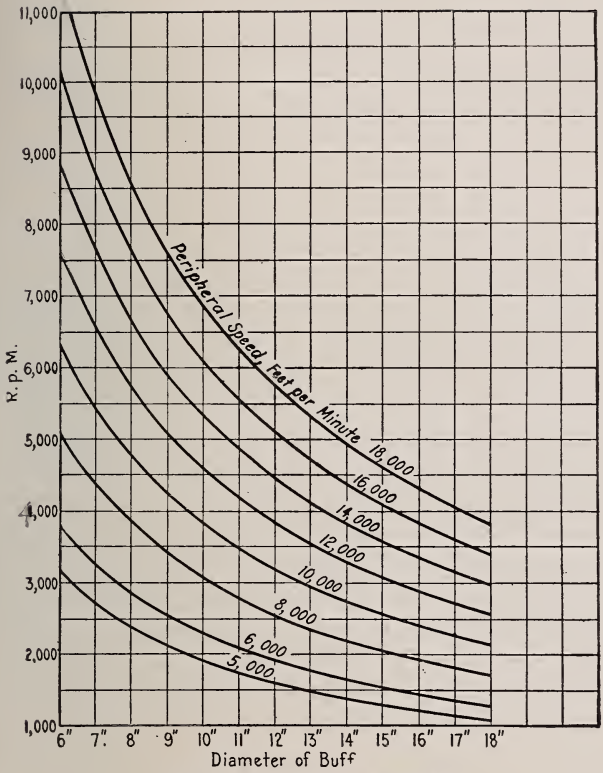

Fig. 137.—Speed of Buffs
(Courtesy of A. P. Munning & Co.)

The above chart shows at what speed any size buff must be run in order to give a predetermined peripheral or cutting speed at the face. For example, suppose we have an 18-inch buff and wish to have 14,000 feet of the edge of the buff pass the surface of the work per minute. Taking the 18-inch line on the base, and following it up to where it crosses the 14,000 curve, then following horizontally to the left, we find that the buff must have a speed of about 3,000 revolutions per minute.

up into the handy cake form shown in Fig. 135. A cutting down composition may also be procured molded into cakes, as shown in Fig. 136.

SPEED OF BUFFS

No definite advice can be given relative to the speed of polishing and buffing wheels. Only the workman, by watching carefully the work he is producing, can judge whether the speed is correct. The chart shown in Fig. 137, however, may be used as a safe guide toward the regulation of buffing speeds.

SCRATCH BRUSHES

There are many instances where treatment with a steel or brass scratch brush improves the surface of an article. Many pleasing effects may be secured on dipped or plated articles if they are lightly touched against a rotating scratch brush. As has been previously stated, the final metal deposit is much improved if the work is removed from the tank, scratch brushed to lay down the grain of the metal, and returned to the solution for the final plating operation. Surfaces thus treated are exceptionally durable. Illustration of a scratch brush is shown in Fig. 104.

BURNISHING BARREL

A power-driven ball-burnishing barrel provides a rapid and quite effective method of burnishing small articles, either before or after plating. Because small steel balls are utilized as burnishing agents, this process is similar to hand work with the exception that

several thousand operations are performed at each revolution of the barrel.

A tumbling barrel cannot be converted for use in steel-ball burnishing. Since this work requires great tool pressure on the part being burnished, the barrel

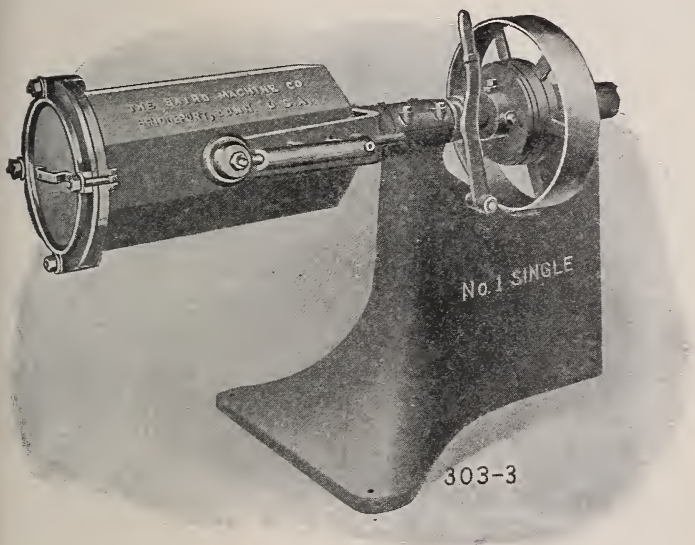

Fig. 138.—Ball Burnishing Machine

(The Baird Machine Co.)

must be designed to concentrate the mass of pieces and balls to gain such weight as will produce the necessary pressure on the bottom layers. As a protection against excessive bruising, a lining of maple, or other hard wood, is provided.

The burnishing process is quite simple. The pieces

to be burnished are placed in the barrel with several hundred pounds of small steel balls. There is little danger of using too large a quantity of steel balls; rather the risk lies in the other direction. A good plan is to allow approximately twice the quantity of balls as of work, so the articles will not strike against

Fig. 139.—No Wave Action in a Full Barrel. The "Baird" Type of Ball Burnishing Machine

each other; but in all instances the barrel must be completely full. Dissolve six to ten ounces of good soap, free from alkali, in a bucket of hot water. As soon as this solution is poured into the barrel, the cover may be secured in place, and the machine set to revolving.

It is suggested that in selecting the size of the balls for burnishing, attention should be given to the character of surface of the articles. Steel balls may be

secured in sizes from ⅛ inch to ½ inch in diameter. For work having crevices or depressions, the smaller size balls will obviously produce the best burnishing effect. A mixture of several sizes is permissible.

The manager of the plating room will find it to his advantage to construct the sifting device shown

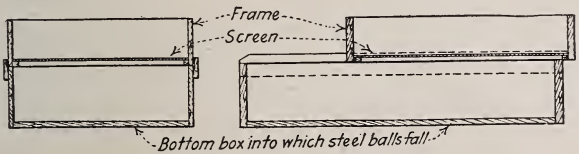

Fig. 140.—Separating Device for Use with Steel Ball Burnishing Barrel

in Fig. 140. It will be seen that an upper frame with a screen bottom rests upon a water-tight box. The latter has the same width as the upper frame but is 24 inches longer. Cleats secured to the upper edges of the box serve to prevent a side movement of the frame, yet allow lengthwise motion. The wire mesh of the frame should be of such coarseness that, when the contents of the barrel are poured into the separating device, the balls will fall through into the box beneath, leaving only the burnished articles on the screen. The upper frame, after the removal of the pieces, may be pushed aside and the steel balls returned to the barrel.

LACQUERING

Tarnish will soon appear on newly-plated work, or articles of brass and copper cleaned by bright dipping. If, however, such new surfaces are protected

from moisture and chemicals by a lacquer coating, the original luster is preserved. Moreover, the article may then be cleaned with a damp cloth without endangering the finish. Most of the brass and nickel-plated hardware, automobile accessories, electrical fixtures, and scientific instruments manufactured at the present time, are treated with either transparent or colored lacquer.

The application of lacquer calls for skill, clean materials and patience. The consistency of the fluid must also always be given careful consideration. If the body is too heavy, a thinner one of the same grade as the lacquer must be added to prevent the formation of ridges or ripples. On the other hand, a lacquer that is too thin will not wear well and may show iridescent colors. The same precautions must be exercised in preparing the work for lacquering as for plating. Grease or moisture is often the cause of a cloudy or spotted finish. Care must therefore be taken to see that steam from the plating and dipping baths does not condense on the articles being prepared for the lacquer application. It is not advisable, however, to hold the work in a drying oven until ready for lacquering, since the best results are obtained when the temperature of the articles, surrounding atmosphere and lacquer are as closely identical as possible.

THE LACQUER ROOM

Ideal conditions for lacquering can only be realized when a separate room is equipped for the work. Such a room should be laid out with as much care and forethought as possible. Ventilators should be so designed

that there will be a constant supply of fresh air and a corresponding removal of all fumes. Dust and moisture, the presence of which will result in inferior work, must positively be eliminated. Efficient lacquering can be accomplished only when the light is sufficiently strong to enable the operator to easily see the results obtained. Since the materials used in compounding lacquer are quite inflammable, the incandescent lamp is the only artificial light that may safely be employed. Stoves should not be used in the lacquer room and heat must, therefore, be obtained from steam or hot water radiators.

A large part of the unpleasant fumes can be eliminated from the work room if the lacquered articles are placed in a ventilated drying oven until the coating has hardened. An oven for this purpose may be constructed in one corner of the room, and should be of sufficient capacity to hold the maximum estimated production. Suitable racks should be placed about the walls for the small articles, while provision should be made for hanging larger work from ceiling hooks. The oven temperature should approximate 100° F. This may be maintained by steam coils, the regulating valves being placed outside the oven to prevent steam from escaping inside.

LACQUER APPLICATION

Lacquer can be applied either by spraying, brushing, or dipping. Spraying is now considered the cheapest and quickest method of lacquering. Shops, therefore, which can obtain a compressed-air supply will find it most advantageous to install the spray system. Under an air pressure of fifty or sixty

pounds per square inch, a spray "pistol", in the hands of a skilled workman, will quickly distribute a thin coating over the most difficult surface. Even should the compressed air supply be unavailable, a small hand sprayer will give satisfactory results.

Fig. 141.—Method of Lacquering by Dipping

(Hanson & Van Winkle Co.)

For brush applications the lacquer should be thinned down to the minimum point consistent with good work. A soft bristle, badger hair brush should be used, flowing the lacquer over the surface in long, even strokes. A perfect finish cannot be obtained with a stiff, inferior brush. The method of lacquering

by dipping, shown in Fig. 141, is used for quick results.

Where it is necessary to lacquer large amounts of articles in a minimum time, and where quantity production is desired rather than quality of finish, the dipping process will prove superior to other methods. The dip tank should be as small as possible, yet of

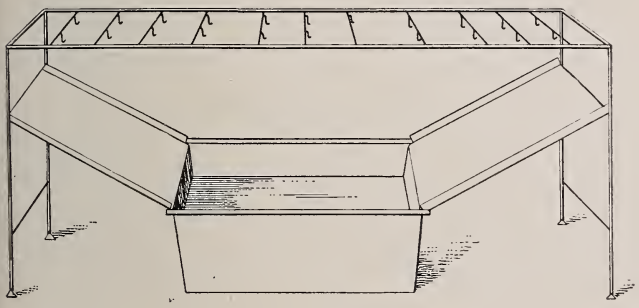

Fig. 142.—Simple Arrangement of Lacquer Dip, Drain Boards, and Drying Rack

sufficient size to handle the articles to be coated. The tank itself should be either enameled iron, glass, or earthenware. Avoid the use of tanks of metal, such as copper, brass, zinc, or galvanized iron; these will soon destroy the original color of the lacquer. Drain trays, arranged as shown in Fig. 142, will permit the surplus lacquer to flow back to the tank as it drips from the dipped work. If a ventilating hood is placed directly over the dip tank and drain trays, the workman will not suffer any inconvenience from the fumes. A cover for the tank should be provided to prevent

evaporation and to keep out dust, grease, and moisture.

Iridescent coloring caused by too thin lacquer, or white, cloudy spots resulting from grease, may often be removed by the application of a second coat of lacquer. If this fails to repair the faulty work, the lacquer may be entirely removed by dipping in hot potash or lye solution.

After cleaning in fresh water and thoroughly drying, the fresh application of lacquer can be made.

COLORED LACQUER

While transparent lacquers are used to a great extent, color finishes can be employed with excellent results. Prepared dyes can be obtained and added to transparent lacquer to produce the desired shade. It is a good plan to mix the colored preparation the day before it is required, since standing improves the solution. Manufacturers, as a rule, produce dyes for special lacquer work and the operator will do well to consult the producer, or a catalogue, to ascertain the grade required for his particular needs.

CHAPTER X

USEFUL REFERENCE DATA

(A) The Maintenance and Repair of a Plating Generator—Building Up—Low Voltage—Reversal of Current Direction—Commutator Sparking—Armature Troubles—Testing for Open Circuit—Testing for Short Circuit—Testing for Grounds—Field Troubles—Bearing Troubles—Unusual Noises—(B) The Transmission of Power—Shaft Drive—Pulleys—Belts—Rules for Speed—(C) Resuscitation from Electric Shock or Asphyxiation—Quick Action—Preliminary Treatment—Loosen Clothing—Resuscitation—Warmth—Patience—(D) Antidote for Poisons—(E) Conductivity of Common Metals—(F) Comparison of Thermometers—(G) Fluxes for Soldering or Welding—(H) Miscellaneous Data—Amperes Required to Plate One Square Foot of Surface—Weight of Metal Deposited per Amperehour—Round Copper Conductors for Plating Currents—Decimal Equivalents.

(A) THE MAINTENANCE AND REPAIR OF A PLATING GENERATOR

Nothing can so retard plating room production as the irregular operation of the generator. An unreliable source of current supply will contribute more than any one thing to poor quality of work and the general inefficiency of the plant. The plating generator is not a machine of mystery. A little care exercised in its management will reward the operator with constant and unfailing service. At times,

however, troubles may arise, and the following suggestions are made with the purpose of assisting the plater to locate and repair them.

BUILDING UP

A self-excited generator may not, upon starting, produce an e.m.f. This may indicate that the residual magnetism in the field poles is insufficient in strength to induce an e.m.f. in the armature windings. The armature e.m.f. serves to increase the field excitation, "building up" the generator as the latter increase continues to induce a larger e.m.f. in the armature.

Should the generator fail to build up, the natural inclination would be to search for a break in the field circuit. Excessive resistance, caused by poor terminal connections, or even light brush contact, might also act to prevent building up. Again, a short circuit in either the field, armature, or outside connections should be looked for. Should investigation fail to disclose any mechanical defects, it will be necessary to disconnect the field from the armature and excite the former for a few moments from some outside source. This operation will strengthen the residual magnetism.

LOW VOLTAGE

Should difficulty be experienced in obtaining the rated voltage, some note should be taken of the shunt field rheostat to determine whether the resistance is excessive. Low voltage is also the result of driving the generator at a speed less than that indicated on the name plate. This may be checked with a speed indicator.

REVERSAL OF CURRENT DIRECTION

The electroplater will quickly recognize a reversal of the current direction. This is caused by a change in the residual magnetism when the machine is idle. Lightning, an outside current, or magnetic influence from a nearby dynamo may effect this reversal in polarity. The remedy is to excite the generator field for a moment in the correct direction from some outside current supply.

COMMUTATOR SPARKING

Undoubtedly the most apparent form of generator trouble is a sparking commutator. There are several causes of poor commutation, the chief of which is an overloaded generator. A simple short circuit, caused by a bar falling across the supply mains, or work touching the anodes in the tanks must be guarded against. Perhaps, also, the generator capacity may be insufficient for the plating requirements.

A rough commutator will always cause sparking. A dark glazed surface is a condition to be strived for. Excessive sparking will quickly groove and pit the commutator and unless some remedy is applied, will injure it beyond repair. A slightly rough surface can be quickly smoothed with fine sand paper. Under no circumstances should emery cloth be used, since the emery dust, which is a conductor of electricity, may lodge between the commutator bars, causing short circuits. If the commutator is very rough, the armature must be removed from the machine, centered in a lathe, and a light cut taken from the pitted copper surface. Often, when the brushes vibrate, the cause

is discovered to be a high or low commutator bar. These bars are often held in place through the aid of a threaded ring on the outside of the commutator. If possible, the bar should be driven back in place and the ring screwed up tight. In this case, it is absolutely necessary that the commutator be trued up in a lathe. To keep the commutator surface clean, it should be treated once a week with vaseline applied with a cloth free from lint. Too much lubrication is, of course, detrimental, since it gums on the brushes and retains dust and grit.

Poor brush contact is another cause of faulty commutation. Graphite-treated woven wire or special brushes for plating generators should always be used. The brush should never fit so tightly in the holder but that the spring can press it snugly against the commutator. The brush pressure may be deemed correct when its bearing against the commutator is about 2 pounds per square inch of contact surface. A small spring scale may be used to determine this pressure. It must be remembered that if the brushes bear too hard they will grind and the copper dust thus formed will lodge between the segments, causing short circuits and sparking.

Weak field excitation may be the cause of sparking brushes. Usually this condition may be determined by noting the voltage across the terminals; a low voltage indicating insufficient field excitation. The remedies for this trouble have already been discussed.

Short circuits and grounds in the armature will produce sparking at the commutator. Tests and remedies for this condition will be described later.

ARMATURE TROUBLES

Should armature trouble appear, it may be due to an open circuit, a short circuit, or a ground in the winding. Excessive heating may also be caused by overloading the generator or by conduction from a defective, hot bearing.

TESTING FOR OPEN CIRCUIT

The usual methods employed in testing for broken armature leads and open circuits are as follows: A strip of brass is substituted for one of the brushes, so that but one commutator segment is touched by it at a time. A low reading ammeter is then connected through a low voltage battery to the brass strip and the other regular brush. The armature is rotated by hand very slowly and the ammeter readings noted. Most plating generators have two leads soldered to each commutator bar; a break in one of these leads causes a reduced ammeter deflection; a break in both causes a complete open circuit and there is no deflection indicated. The broken lead may be traced from the bar upon which the brass strip rests at the moment of reduced ammeter deflection.

Open circuits are found by testing in a manner similar to that just described. Instead, however, of connecting one meter lead to the regular brush, contact is made with the commutator by a second brass strip. This latter strip is so held that it at all times touches a bar adjacent to one upon which the first brass strip rests. As in the first test, an open circuit is indicated by no deflection of the ammeter. It is, of course, understood that there will be no deflection

of the pointer as the strips pass over the insulating mica when the armature is rotated. There should be no confusion of this with the action of the meter when an actual broken circuit is found.

TESTING FOR SHORT CIRCUITS

A short circuit in an armature is found with the same equipment as required for the open circuit test. As the two brass strips are touched against adjacent commutator bars and the armature slowly rotated, an ammeter reading above normal indicates a short circuit in the coil section connected to one of the bars.

TESTING FOR GROUNDS

A ground is any connection between a winding and the core or frame. Grounds in an armature are usually found by connecting a battery to the brushes of the generator. A low-reading voltmeter is then observed while one of its leads is touched against each commutator bar, the other lead being in contact with the shaft or core iron. A voltmeter deflection indicates, of course, that there is a ground or connection between the core and the winding. The ground may be localized by noting the bar where the voltmeter shows the least deflection.

FIELD TROUBLES

As a rule, the field gives very little trouble. Excessive heating may be traced to a short circuit, to high terminal voltage, or to the conduction of heat from the armature. A short circuit may be easily located by noting, with a voltmeter, the difference of potential cross each field winding. An open cir-

cuit or an exceptionally high resistance can be noted by connecting a battery and ammeter in series with each of the coils in turn. If there is no deflection of the pointer it will naturally indicate an open circuit.

BEARING TROUBLE

Bearing friction absorbs power, causes wear, and, if the friction is excessive, produces great heat. Clean, smooth bearing surfaces, between which is a thin film of good lubricant, should show but a slight rise in temperature. A good grade of mineral oil should be freely used; if possible, the oil wells should be filled each day. Abrasive dust from the polishing room may work into the bearings, causing a scored and roughened shaft. Bearing alignment is quite important, as is also the shaft and bearing fit. Precautions should be taken to guard against bending the shaft, since excessive vibration will then result.

UNUSUAL NOISES

Any large generator produces certain characteristic noises while operating. It is the unusual noise that should be at once noted by the plater and an investigation made as to its cause. A slipping belt gives a screeching sound. This may be due to insufficient belt tension, but usually it is caused by an overload thrown on the generator. Adjustments should be so made that there will be little pounding of the belt. If a scraping noise is heard, the generator should be immediately stopped. It may be found that a pole shoe is loose, that the bearings have worn to such an extent that the armature is rubbing against the field poles, or that the armature is un-

balanced. Commutator noises may be due to roughness, chattering of brushes, or the need of a lubricant. Remedies for these troubles have already been suggested.

(B) THE TRANSMISSION OF POWER

While the subject of mechanical power transmission does not concern the electroplater to so great a degree as it does a machine shop superintendent, yet a few simple precautions taken at first will prevent interrupted service at a later time.

SHAFT DRIVE

If it is necessary to use overhead shaft drive for the various machines, care should be exercised to place the hangers in alignment. Should the distance between the hangers be so great as to allow the shaft to bend, even slightly, the wear on the bearings will be excessive. Compute carefully the size of shaft required to transmit the required power; then allow a good factor of safety. It will be remembered that the slower the shaft speed, the less power it will safely transmit. Countershafts, which are run at a slow speed should, therefore, have a larger diameter than the drive shafts.

PULLEYS

Ordinarily, paper or wooden pulleys will give better satisfaction than iron ones; the friction is greater and they are much lighter. When pulleys are to be added to a shaft, split iron or pressed steel pulleys may be used to advantage, since they may be installed without disturbing the shaft.

BELTS

Although in many instances it is necessary, on account of lack of space, to mount the motor on the ceiling, such mounting demands a vertical belt drive; an inclined belt will give better results, and one that is horizontal is best of all. Long belts need not be drawn as tightly as short ones to produce the same friction; yet there is a limit even to the length. Harmful bearing friction and an injurious side to side motion of the belt are direct results of long distance between pulley centers.

RULES FOR SPEED

The electroplater is often confronted with the problem of determining the speed of shafts, countershafts, and machines, as well as the size of the required pulleys and belts. Such information may be obtained from the manufacturers of the apparatus in question, but for the convenience of the plater, the following rules are quoted, through the courtesy of the Crown Rheostat and Supply Co.:

"To find speed of countershaft in accordance with main shaft and machine. Subtract the number of revolutions of the main shaft from the number of revolutions the machine should make; divide the remainder by two. The quotient will show the number of revolutions of the countershaft.

"Example: The main shaft runs 200 revolutions per minute, while the machine should run 1,000 revolutions per minute. Deduct 200 from 1,000, leaving 800, which divide by 2; the quotient will then be 400, which is the number of revolutions the countershaft should make.

"To find diameter of pulleys on the main shaft. Multiply the diameter in inches of the receiving pulley of the countershaft by the number of revolutions the countershaft should make, and divide the product by the number of revolutions the main shaft makes.

"Example: The countershaft runs 400, the receiving pulley is 7½ inches in diameter, and the mainshaft runs 200; 400 times 7½ equals 3,000, which divided by 200 equals 15; this is the diameter of pulley on main shaft in inches.

"To find diameter of pulley on countershaft carrying belt to machine. Multiply the number of revolutions the machine should make by the diameter of pulley of machine and divide by the number of revolutions the countershaft makes.

"Example: Say machine should make 1,000 revolutions, the diameter of pulley on machine being 6 inches, and the countershaft making 400 revolutions, then multiplying 1,000 by 6 equals 6,000; dividing this by 400 gives 15, which should be the diameter of pulley carrying belt from countershaft to machine.

"To find speed of a machine. Multiply the number of revolutions of the main shaft by the diameter of pulley in inches, and divide by the diameter of receiving pulley of the countershaft. The result is speed of countershaft. Then multiply the number of revolutions of countershaft by diameter of transmitting pulley, and divide by diameter of pulley on machine. The result will be speed of machine. It should be well understood that no other pulleys but those in contact with one belt should be considered. To find the horse-power a belt will safely transmit.

Multiply diameter of pulley in inches by its revolutions per minute and the product by width of belt in inches. Divide this product by 3,000 for single belting or 2,100 for double belting, and the quotient will be the horse-power that can be safely transmitted. To find the length of the belt. Add the diameters of the two pulleys, divide by 2 and multiply by 3.1416. To this add twice the distance between centers of pulleys. This is practically correct where pulleys are not very different in size, and are to run with short belt.

"A belt velocity of 2,600 feet per minute is said to give the best results."

(C) RESUSCITATION FROM ELECTRIC SHOCK OR ASPHYXIATION

It is, of course, understood that the low voltages required for electroplating are by no means dangerous to human life. If, however, the plating generator is driven by an electric motor, a time may come when an inspection or a repair job will expose the workman to an outside power circuit of 220 to 440 volts. While a normal, healthy person will usually rally promptly from a slight shock at these voltages, instances are on record of mortalities caused by shock from currents of even lower pressure. Since the method of resuscitation from electric shock is quite similar to that from asphyxiation by poisonous vapors, a brief discussion of the subject will benefit the electroplater who is often exposed to both dangers.

QUICK ACTION

Good judgment will prompt, in the case of any accident, the placing of an immediate call for the nearest doctor. Realizing that the spark of life is hanging by the merest thread, those attending the patient will act quickly and continue their efforts with patience. In the case of gas or poisonous vapor asphyxiation, the patient should be removed at once to fresh air before the acts of resuscitation are begun. Not so with a case of electric shock. The loss of a few seconds may cause death; the work of resuscitation should be started at the earliest possible moment regardless of the position of the unconscious man.

PRELIMINARY TREATMENT

If the accident is caused by electric shock, search for and remove the wires or other conductors from contact with the injured man's body, using a board or other non-metallic agent. If the tongue appears to be swallowed, pry open the mouth with a stick of wood and pull the tongue out using a cloth or handkerchief to obtain a better grip. The tongue must then be held out to prevent it again plugging up the throat.

LOOSEN CLOTHING

For either shock or asphyxiation, loosen at once all clothing. But since the body heat must be retained to as great extent as possible, do not remove any but the tight throat apparel, such as collar or scarf.

RESUSCITATION

Lay the patient on his back, and, if convenient, arrange the head lower than the feet. Assume a kneeling position at the head of the patient. Grasping his arms at the wrists, place them over the lower ribs and press, immediately afterward swinging the arms directly up and backward, then downward again to repeat the pressing operation. Expel and fill the man's lungs in this manner sixteen times a minute in imitation of the normal breathing action. A hissing of the expelled air will indicate the work of resuscitation is being carried out correctly.

If a helper is available, the work may be accomplished more quickly and with promise of greater success by having him move the patient's legs, bending them at the knees so that the latter move upward and toward the breast at the time that the arms are extended backward. As the air is expelled from the lungs, the legs should be pulled out straight.

WARMTH

At all times the patient should be kept as warm as it is possible to make him. Wrap the exposed parts in blankets without, of course, interfering with the work of resuscitation. Do not administer hot or cold drinks until the patient is sitting up, as the possibility of choking must be avoided.

PATIENCE

It may be well to add that consciousness is not always restored in a few minutes. Results may not

be seen for one, two, or even four hours in severe cases. But while there is the faintest spark of life there is something well worth working for, and no amount of fatigue should cause one to give up. Not until death has actually occurred, as may be known by the softening of the patients eyeballs, is there no hope for success.

(D) ANTIDOTES FOR POISONS

The majority of the chemicals used in electroplating are poisonous, and workmen should exercise the greatest precautions to safeguard their health. Plating room utensils should under no circumstances be used for drinking cups. It is dangerous practice to eat lunches where the chemicals are stored. Work that has dropped off the wires into the electrolyte should be recovered with some mechanical device; to dip the arms into the solution may result in skin sores, especially if it is a cyanide solution. In case of accident the following remedies will give relief until the doctor arrives:

HYDROCHLORIC ACID

If the acid solution has been swallowed, require the patient to drink tepid water to act as an emetic or an alkali solution, such as magnesia, lime, or chalk and water, to counteract the effect of the acid. Milk or the white of eggs may be used if available.

SULPHURIC ACID

Treatment same as for hydrochloric acid poisoning.

NITRIC ACID

Treatment same as for hydrochloric acid poisoning.

HYDROCYANIC ACID

Take hydrogen peroxide internally. If this antidote is not available, administer a weak solution of iron acetate. Employ artificial respiration if necessary. Keep the patient warm.

POTASSIUM CYANIDE

Treatment same as for hydrocyanic acid poisoning.

LEAD ACETATE

Administer an emetic; give milk, white of eggs.

SILVER NITRATE

Require the patient to drink salt and water solution.

SODIUM HYDROXIDE

Give vinegar, lemon juice, oil, or milk.

POTASSIUM HYDROXIDE

Treatment same as for sodium hydroxide poisoning.

COPPER SALTS

Administer an emetic, then milk or white of egg.

MERCURY SALTS

Require the patient to swallow the white of an egg.

ALKALINES

Since alkalines are the opposite to acids in chemical action, weak acid solutions may be employed as antidotes. Vinegar or lemonade is the best, but if neither is available, a *very* weak solution of nitric or sulphuric acid may be used. It is advisable to give the patient a tablespoonful of olive oil a few minutes after the acid treatment.

ACID VAPORS

Remove the patient at once to a location where there is plenty of fresh air. Cause him to inhale ammonia vapor. Keep him warm with hot blankets. Give hot foot baths. Require him to drink hot coffee, tea, or other hot beverage. Note section C.

BURNS AND SCALDS

Apply at once a light paste of baking soda or, if this is not available, starch or flour. Vaseline, vegetable oils, and cream are also soothing. Linseed oil mixed with an equal part of lime water makes a good dressing. After treating, cover the affected part with a light bandage to prevent foreign matter touching the wound.

In the case of acid or alkali burns, wash with running water. Acid burns should then be treated with lime water and linseed oil, or baking soda and soap suds. Eye burns should be bathed with lime water.

Alkali burns may best be treated by neutralizing the alkali with a weak acid, such as lemon juice, cider, or vinegar. Eye burns should be treated at once with olive oil or a solution of boric acid.

(E) CONDUCTIVITY OF COMMON METALS

Copper, because it offers the least resistance to the passage of an electric current of any metal except silver, is the metal used for most conductors. The following table, using silver as a standard, gives the relative conductivity of the common metals. When it is noted that brass has approximately 4½ times the resistance of copper, it will be seen why the latter metal is preferred for bus bars and other plating room electrical conductors.

Silver	100.00
Copper	99.9
Gold	80.00
Aluminum	34.00
Zinc	29.00
Brass	22.00
Platinum	18.00
Iron	16.8
Tin	13.1
Nickel	12.08
Lead	8.3
German Silver	7.7
Mercury	1.7

(F) COMPARISON OF THERMOMETERS

Freezing point	32°	Fahrenheit
Do.	0°	Centigrade
Boiling point	212°	Fahrenheit
Do.	100°	Centigrade

To find Fahrenheit reading, Centigrade being known:

$$F = C \times 9/5 + 32°$$

To find Centigrade reading, Fahrenheit being known:

$$C = (F - 32) \times 5/9$$

(G) MISCELLANEOUS DATA

SIZES OF MAIN CONDUCTORS

to carry a given number of amperes various distances from dynamo to tanks

(Courtesy Crown Rheostat & Supply Co.)

	DISTANCE IN FEET FROM DYNAMO TO TANKS											
Amp.	15	20	25	30	35	40	45	50	55	60	65	70
50	1/8	1/4	1/4	1/4	1/4	5/16	5/16	5/16	5/16	3/8	3/8	3/8
75	1/4	3/16	1/4	5/16	5/16	3/8	3/8	3/8	7/16	7/16	7/16	7/16
100	1/4	5/16	5/16	3/8	3/8	3/8	7/16	7/16	1/2	1/2	1/2	9/16
125	1/4	5/16	3/8	3/8	7/16	7/16	1/2	1/2	9/16	9/16	9/16	5/8
150	5/16	3/8	3/8	7/16	7/16	1/2	1/2	9/16	9/16	5/8	5/8	11/16
175	5/16	3/8	7/16	1/2	1/2	9/16	9/16	5/8	5/8	11/16	11/16	11/16
200	3/8	3/8	7/16	1/2	9/16	9/16	5/8	5/8	11/16	11/16	3/4	3/4
250	3/8	7/16	1/2	9/16	5/8	5/8	11/16	3/4	3/4	13/16	13/16	7/8
300	7/16	1/2	9/16	5/8	11/16	11/16	3/4	13/16	13/16	7/8	7/8	15/16
350	1/2	9/16	5/8	11/16	3/4	3/4	13/16	7/8	7/8	15/16	1	1

400	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1	2x1/2	2x1/2	
450	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1	2x1/2	2x1/2	2x1/2	
500	9/16	5/8	3/4	13/16	7/8	15/16	1	2x1/2	2x1/2	2x1/2	4x3/8	4x3/8
600	2x1/4	2x1/4	2x1/4	2x1/2	2x1/2	2x1/2	2x1/2	2x1/2	4x3/8	4x3/8	4x3/8	4x3/8
700	2x1/4	2x1/4	2x1/2	2x1/2	2x1/2	2x1/2	2x1/2	4x3/8	4x3/8	4x3/8	4x3/8	4x1/2
800	2x1/4	2x1/4	2x1/2	2x1/2	2x1/2	2x1/2	4x3/8	4x3/8	4x3/8	4x3/8	4x1/2	4x1/2
900	2x1/4	2x1/2	2x1/2	2x1/2	2x1/2	4x3/8	4x3/8	4x3/8	4x1/2	4x1/2	4x1/2	4x1/2
1000	2x1/4	2x1/2	2x1/2	2x1/2	4x3/8	4x3/8	4x3/8	4x1/2	4x1/2	4x1/2	4x5/8	4x5/8
1100	2x1/4	2x1/2	2x1/2	4x3/8	4x3/8	4x3/8	4x1/2	4x1/2	4x1/2	4x5/8	4x5/8	4x5/8
1200	2x1/2	2x1/2	2x1/2	4x3/8	4x3/8	4x3/8	4x1/2	4x1/2	4x5/8	4x5/8	4x5/8	4x3/4
1300	2x1/2	2x1/2	2x1/2	4x3/8	4x3/8	4x1/2	4x1/2	4x5/8	4x5/8	4x5/8	4x3/4	4x3/4
1400	2x1/2	2x1/2	4x3/8	4x3/8	4x1/2	4x1/2	4x1/2	4x5/8	4x5/8	4x3/4	4x3/4	4x7/8
1500	2x1/2	2x1/2	4x3/8	4x3/8	4x1/2	4x1/2	4x5/8	4x5/8	4x3/4	4x3/4	4x7/8	4x7/8
1600	2x1/2	2x1/2	4x3/8	4x3/8	4x1/2	4x1/2	4x5/8	4x3/4	4x3/4	4x7/8	4x7/8	4x 1
1700	2x1/2	4x3/8	4x3/8	4x1/2	4x1/2	4x5/8	4x5/8	4x3/4	4x3/4	4x7/8	4x7/8	4x 1
1800	2x1/2	4x3/8	4x3/8	4x1/2	4x1/2	4x5/8	4x3/4	4x3/4	4x7/8	4x7/8	4x 1	4x 1
1900	2x1/2	4x3/8	4x3/8	4x1/2	4x5/8	4x5/8	4x3/4	4x3/4	4x7/8	4x 1	4x 1	
2000	2x1/2	4x3/8	4x1/2	4x1/2	4x5/8	4x5/8	4x3/4	4x7/8	4x7/8	4x 1		
2100	2x1/2	4x3/8	4x1/2	4x1/2	4x5/8	4x3/4	4x3/4	4x7/8	4x 1	4x 1		
2200	2x1/2	4x3/8	4x1/2	4x5/8	4x5/8	4x3/4	4x7/8	4x7/8	4x 1			
2300	4x3/8	4x3/8	4x1/2	4x5/8	4x3/4	4x3/4	4x7/8	4x 1	4x 1			
2400	4x3/8	4x3/8	4x1/2	4x5/8	4x3/4	4x7/8	4x7/8	4x 1				
2500	4x3/8	4x1/2	4x1/2	4x5/8	4x3/4	4x7/8	4x 1	4x 1				

(H) FLUXES FOR SOLDERING OR WELDING

Brass	Sal Ammoniac
Copper	Sal Ammoniac
Lead	Resin and Tallow
Lead Pipes	Resin and Sweet Oil
Iron	Borax
Iron (Tinned)	Resin
Tin Pipes	Resin and Sweet Oil
Zinc	Zinc Chloride

ROUND COPPER CONDUCTORS FOR PLATING CURRENTS

B. & S. Gauge	Dia. Inches	Capacity Amperes	Resistance per 1000 ft. in ohms	Weight per 1000 ft. in lbs.
0000	.460	300	.0489	63
000	.409	245	.0617	50
00	.364	215	.0778	40
0	.324	190	.0981	31
1	.289	160	.1237	25
2	.258	135	.1560	20
3	.230	115	.1967	16
4	.204	100	.2480	13
8	.129	60	.6271	5
12	.080	30	1.586	2
16	.050	15	4.009	0.78

AMPERES REQUIRED TO PLATE ONE SQUARE FOOT OF SURFACE

(Courtesy of A. P. Munning & Co.)

METAL	AMPERES
Nickel	4
Brass	6–8
Bronze	6–8
Copper (Alkali)	6–8
Copper (Acid)	10–30
Silver	2
Zinc	1½
Gold	10

DECIMAL EQUIVALENTS

1/32	.0312	17/32	.5312
1/16	.0625	9/16	.5625
3/32	.0937	19/32	.5937
1/8	.125	5/8	.625
5/32	.1562	21/32	.6562
3/16	.1875	11/16	.6875
7/32	.2187	23/32	.7187
1/4	.250	3/4	.750
9/32	.2812	25/32	.7812
5/16	.3125	13/16	.8125
11/32	.3437	27/32	.8437
3/8	.375	7/8	.875
13/32	.4062	29/32	.9062
7/16	.4375	15/16	.9375
15/32	.4687	31/32	.9687
1/2	.500	32/32	1.000

WEIGHT OF METAL DEPOSITED PER AMPERE HOUR

(Courtesy of A. P. Munning & Co.)

(ENGLISH SYSTEM)

.0415 oz.	Copper (Acid)
.0836 oz.	Copper (Cyanide)
.0862 oz.	Gold
.136 oz.	Lead
.0377 oz.	Nickel
.119 oz.	Silver
.0782 oz.	Tin
.0428 oz.	Zinc

(METRIC SYSTEM)

1.176 grams	Copper (Acid)
2.372 grams	Copper (Cyanide)
2.444 grams	Gold
3.858 grams	Lead
1.069 grams	Nickel
3.373 grams	Silver
2.218 grams	Tin
1.213 grams	Zinc

WEIGHTS AND MEASURES

AVOIRDUPOIS WEIGHTS

16 drams	1 ounce
16 ounces	1 pound
100 pounds	1 cwt.
2000 pounds	1 short ton
2240 pounds	1 long ton

TROY WEIGHTS

24 grains	1 dwt.
20 dwts.	1 ounce
12 ounces	1 pound

Used for weighing gold, silver, and precious stones.

APOTHECARIES' WEIGHTS

20 grains	1 scruple
3 scruples	1 dram
8 drams	1 ounce
12 ounces	1 pound

METRIC WEIGHTS

10 milligrams	1 centigram
10 centigrams	1 decigram
10 decigrams	1 gram
1000 grams	1 kilogram

ENGLISH LENGTH MEASURE

12 inches	1 foot
3 feet	1 yard
5280 feet	1 mile

METRIC LENGTH MEASURE

10 millimeters	1 centimeter
10 centimeters	1 decimeter
10 decimeters	1 meter

ENGLISH SQUARE MEASURE

144 sq. inches	1 sq. foot
9 sq. feet	1 sq. yard

METRIC SQUARE MEASURE

100 sq. millimeters	1 sq. centimeter
100 sq. centimeters	1 sq. decimeter
100 sq. decimeters	1 square meter

ENGLISH CUBIC MEASURE

1728 cubic inches	1 cubic foot
27 cubic feet	1 cubic yard
40 cubic feet	1 shipping ton
231 cubic inches	1 gallon

METRIC CUBIC MEASURE

1000 cubic millimeters	1 cubic centimeter
1000 cubic centimeters	1 cubic decimeter
1000 cubic decimeters	1 cubic meter

LIQUID MEASURE

4 gills	1 pint
2 pints	1 quart
31½ gallons	1 barrel
2 barrels	1 hogshead

METRIC EQUIVALENTS

LINEAR MEASURE

1 centimeter	0.3937 inch
1 decimeter	3.937 inches
1 meter	39.37 inches
1 kilometer	0.6214 mile
1 inch	2.54 centimeters
1 foot	3.048 decimeters
1 yard	0.9144 meter
1 mile	1.6093 kilometers

SQUARE MEASURE

1 sq. centimeter	0.155 sq. inch
1 sq. decimeter	0.1076 sq. foot
1 sq. meter	1.196 sq. yards
1 sq. kilometer	0.386 sq. mile
1 sq. inch	6.452 sq. centimeters
1 sq. foot	9.290 sq. decimeters
1 sq. yard	0.8361 sq. meter
1 sq. mile	2.59 sq. kilometers

WEIGHTS

1 gram	0.0353 ounce
1 kilogram	2.2046 pounds
1 metric ton	1.1023 English tons
1 ounce	28.85 grams
1 pound	0.4536 kilogram
1 English ton	0.9072 metric ton

VOLUME

1 cu. centimeter	0.061 cu. inch
1 cu. decimeter	0.035 cu. foot
1 cu. meter	1.308 cu. yard
1 liter	1.057 quart liquid
1 cu. inch	16.39 cu. centimeters
1 cu. foot	28.32 cu. decimeters
1 cu. yard	0.765 cu. meter
1 quart liquid	0.946 liter
1 gallon	0.378 decaliter

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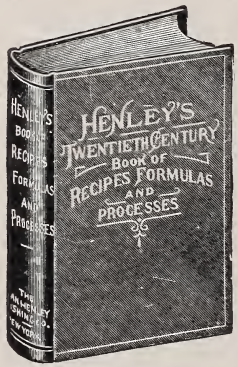

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